The Republic of Malawi
Ministry of Agriculture, Irrigation and Water Development
Lilongwe Water Board

PREPARATORY SURVEY FOR THE PROJECT FOR IMPROVEMENT OF GROUNDWATER DEVELOPMENT AND NON-REVENUE WATER REDUCTION IN MALAWI

FINAL REPORT

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Summary

1. Overview of Malawi

1-1 Natural Conditions

Malawi is situated in the southeastern part of the continent of Africa between latitudes 9°～17° south and longitude 33°～36° east. The country extends from north to south (855 km), and it is bordered by Mozambique to the southeast, Zambia to the west and Tanzania to the north. It has a geographical area of 118,000 km2, of which one fifth is occupied by Lake Malawi (23,000 km2). Malawi belongs to the tropical savanna climate. The seasons are divided into rainy season (November to March) and dry season (April to October). Annual rainfall of around 1,000 mm is expected through the entire area except steep mountainous areas. The average temperature is 16 to 21 °C from April to September and 23 to 24 °C from October to December. It is around 22 °C during January to March because hours of daylight is shorter when there is higher rainfall.

1-2 Socio-Economic Status

Malawi is located in the southeastern part of African continent and is an inland country surrounded by Tanzania in the north, Zambia in the west and Mozambique in the southeast. The population is estimated at 18.1 million people, the population growth rate is 3.0%, and the per capita Gross National Income (GNI) is 320 USD according to the World Bank (2016).

The economy of Malawi is predominantly agricultural, which accounts nearly 80 percent of total employment. More than 80 percent of the country's total exports (10.8 billion USD) are agricultural commodities, primarily tobacco, sugar and tea. However, the price of agricultural products are easily impacted by foreign exchange rates and thus its economy is fragile. In the past, economic growth rate of more than 6% has been achieved; however, international agricultural prices have fallen heavily since the global financial crisis in 2008 and the subsequent stagnation of the world economy, and the rate of economic growth has slumped to 2.8%. In addition, the inflation rate is high at 21.2% and the unemployment rate is at a high level of 7.5%. It is an urgent issue to rebuild social economy of Malawi through reforming the economic structure and securing new foreign capital.

2. Background and Outline of the Project

2-1 Overall Plan

(1) Groundwater Development

1) Malawi Rural Water Investment Plan

Ministry of Agriculture, Irrigation and Water Development (MAIWD) has established Malawi Rural Water Supply Investment Plan 2014-2020 and a groundwater development plan in Malawi by 2020 to promote Malawi Growth and Development Strategy II 2012-2016 (MGDS II). The plan sets quantitative indicators to improve the access rate of safe water in rural areas to 83% by 2015, 85% by 2017 and 90% by 2020. It is necessary to rehabilitate and expand existing facilities and to establish a surface- and groundwater-based Gravity-Fed Piped Scheme (Level 2 water supply facility) in order to achieve these quantitative indicators.

Specific numerical targets for groundwater development are as follows.

- Drilling of over 8,102 new boreholes fitted with hand pumps for the total population of 2,065,000.
- Construction of groundwater-based Gravity-Fed Piped Scheme in 32 market centers for the total population of 197,005

Above plans aim to develop shallow aquifers by drilling several boreholes at a depth of 40 to 55 m in market centers with great water demand. The plan stipulates neither development plan for groundwater deeper than 100 m nor its necessity.

2) Groundwater Development Plan in Urban Areas

In Malawi, five Water Boards (Lilongwe, Blantyre, North, Central and South) were established as semi-governmental organizations based on the Waterworks Act enforced in 1995. Water Boards are responsible to develop plans for water facilities (Level 2 or 3 water supply facilities) in urban areas and small cities with relatively high water revenues. Meanwhile, MAIWD is in charge of establishing development plans for water facilities (Level 1 water supply facilities) in rural areas including market centers. Although the major water source in urban areas is rivers, Lilongwe Water Board (LWB), which has jurisdiction over Lilongwe City, refers to groundwater development in their development plan. Details of the contents are as follows.

- LWB Strategic Plan 2015-2020
  - ▷ Development of groundwater resources in Lumbadzi, Chitedze and Mchezi located within 20 km of Lilongwe City (FY 2015/16 – FY 2016/17)
- Infrastructure Investment Plan for LWB 2016-2026
  - ▷ Implementation of groundwater development surveys aiming to prepare a hydrogeological report (Budget: approx. 0.1 million USD)
  - ▷ Development of a groundwater resource aiming to construct boreholes for improved water supply in Lilongwe City (Budget: approx. 1.67 million USD)

Although LWB is considering developing groundwater resources, they placed the highest priority on NRW reduction, customer services and enhancement of organizational capacity to improve water supply situation in Lilongwe. In addition, the Project for National Water Resources Master Plan in the Republic of Malawi, supported by JICA, recommends using groundwater resources for increasing Malawi's water supply. Nevertheless, detailed measures are not proposed in the report.

(2) Non-Revenue Water Reduction

1) LWB Strategic Plan

LWB, which has jurisdiction over the water supply in Lilongwe City, placed a high priority on making maximum use of the limited water resource of Lilongwe River, located downstream of Kamuzu Dam, in line with MGDS II. LWB established the LWB Strategic Plan 2015-2020 (Strategic Plan) to make the most use of water resource and clarify four (4) strategic issues as follows.

- Unreliable Water Supply Service
- Weak Customer Relations

- Limited Financial Capacity for Infrastructure Development
- Inadequate Institutional Capacity

Under the Strategic Plan, implementation plans for each issue have been established, including the contents of activities, target values and implementation year. These implementation plans contain details on maintenance and renewal of facilities and equipment, such as renovation and raising of Kamuzu Dam; expansion of booster pump stations; procurement of compacters and small excavators; and expansion of office and training for staff. The investment cost is estimated as 1.2 million USD for the next 5 years. A small-scale plan has been budgeted by LWB, though source of funding has not yet been specifically determined for most of the construction work that required support from donors such as expansion of facilities. Neither has an operation plan been conceptualized as yet.

2) LWB Infrastructure Investment Plan

LWB established the "Infrastructure Investment Plan for LWB 2016-2026" for rectifying increasing gap between water demand and supply. The investment plan defines a plan that takes 1-2 years to have an impact on beneficiaries as "short-term", a plan that takes 3-5 years to have an impact as "middle-term," and a plan that takes 6-10 years as "long-term". Although the investment plan stipulates outline costs and sources of funding, details of plans have not yet taken shape except for projects such as renewal of Diamphwe Dam, associated facilities, water treatment plant and transportation pipeline as well as renovation and raising of Kamuzu Dam I, implementation of SCADA and procurement of 23,500 units of pre-paid water meters.

3) Non-Revenue Water Reduction Strategy

LWB recognized the high level of non-revenue water (NRW) rate in Lilongwe City as a serious issue and factors are organized as follows in "Non-Revenue Water Reduction Strategy" (October 2016).

- Physical loss (leakage and pipe bursts ; and leakage due to reservoir overflow)
- Commercial loss (error of meter reading, illegal connections and water theft)
- Unbilled water consumption (operational use such as firefighting)

The Strategy aims to reduce the NRW rate (36%) to 25% in 3 years from FY 2015/16 and thus, a comprehensive strategy is necessary.

LWB plans to the following NRW reduction activities to conduct: repairing parts of leakage; installation and replacement of water meters; inspection for illegal connections; monitoring of water storage tanks in buildings; measurement of water flow; and analysis and evaluation of water balance. In addition, the Strategy aims to repair leaks to a maximum of 2 days two days isolate burst pipes within 30 minutes after receiving reports. It classifies activities of NRW reduction into three stages and plans to allocate the budget and implement these activities gradually.

LWB provides funds for implementing of all activities. The progress of activities are under the second stage; details are as follows.

- Establishment of District Metered Area (DMA) through installation of flow meters
  …….106 DMA have been installed
- Calculation of NRW rate for each DMA……..Calculation system has not yet established

- Installation of water meter……Currently installing
- Leak detection activity…….....Technical skills on leak detection have not been acquired
- Update of GIS data……..……...Currently updating

4) Priority Investment Program 2016 to 2037

LWB established “Priority Investment Program 2016 to 2037” besides the above plan and strategy, which defines priorities for maintenance.

The Program prioritized the maintenance for each water supply facility based on the future water demand.Only the rehabilitation of transmission and distribution pipes, supported by European Investment Bank (EIB) and WB has a hope to be realized under the Program.

The Program has established priorities on the facility maintenance, though supporting organizations and/or donors have not yet been decided except EIB and WB.

2-2 Status and Issues

(1) Groundwater Development

The Government of Malawi placed a high priority on water resource development in line with the MGDS II. It is aimed to increase the rate of access to safe drinking water in Lilongwe and rural areas through development of confined aquifers (assumed drilling depth is at 50 to 100 m). At present, development of shallow aquifers at a depth of 40 to 60 m is promoted.

However, some shallow aquifers cannot secure the sufficient amount of water and some areas contain salinity or iron, and thus development of deep aquifers is highly requested. In addition, there is almost no data obtained through exploration and analysis of underground geological structure deeper than 100 m in Malawi. Moreover, not only MAIWD, which is in charge of planning, implementing and managing groundwater development, but also private drilling companies do not own rigs capable of developing aquifers at 100 m or deeper. Therefore, there is currently no progress being made on developing new water resources in rural areas of Malawi.

(2) NRW Reduction

Planning, construction and management of water supply in urban areas in Malawi is implemented by five Water Boards (Lilongwe, Blantyre, North, Central and South).

Each Water Board have been working on water resource development according to MGDS II. LWB, which has jurisdiction over the water supply in Lilongwe City, placed a high priority on making maximum use of the limited water resource of Lilongwe River, located downstream of Kamuzu Dam. LWB established the Strategic Plan 2015-2020 to make the most use of water resources and aims to reduce the NRW rate (36%) in 2015 to 28% by 2020.

Despite the situation that LWB is actively working on NRW reduction and other donors are supporting the activities, the effect of NRW reduction is limited.

2-3 Background and Outline of Grant Aid

The population growth rate of Lilongwe City, the capital of Malawi, is higher (4.3%) than that of national average (2.8%) according to the 1998 and 2008 census. Accordingly, the increasing demand for water is remarkable in the city; it is about 135,000 m3/day that is far greater than the current water production volume

(92,441 m3/day). In addition, the proportion of unbilled water (Non-Revenue Water) is as high as 37.9% (2016) due to water leakage caused by aging water distribution pipes, construction failures and misreading of water meters. These factors are negatively affecting the water demand and supply balance. Under such circumstances, the period of water supply has been decreasing over the past few years. It was 24 hours of water supply in 2010; however, it was 22 hours/day in 2011 and 20 hours/day in 2012. In particular, the shortage of water in 2016 was serious and water distribution in the City was forced to be cut to up to half of the usual amount between April and November 2011. As a result, suspension of water supply occurred three days a week and it had an extensive impact on civic life as well as on industries and administrative functions of the capital. Furthermore, apart from Lilongwe City, water shortages in rural areas are particularly serious, with 3 million people, which is equivalent to 30% of the population of village areas, unable to access safe drinking water.

The Government of Malawi prioritized water resource development in MGDS II in order to improve the above situation. Nevertheless, they have difficulty with securing funds for new water resource development in Lilongwe City and it is not progressing as expected. Thus, LWB is working on maximizing the existing water resources and reducing NRW rate to 28% by 2020 in the Strategic Plan. The effect, however, is limited.

On the other hand, MAIWD plans to develop shallow aquifers of groundwater in rural areas, where people are dependent on groundwater resources. Neither MAIWD nor private drilling companies own rigs capable of drilling 100 m or deeper and thus, the development is not progressing as expected.

In response to these situations, the Government of Malawi requested Grant Aid with regard to maintenance of equipment for groundwater development and NRW reduction. The contents of the request from the Government of Malawi during the first Survey is as shown in the table below. The relevance of equipment procurement is examined according to contents of the table.

Table 1 : Request for equipment procurement from Malawian side (during the first Survey)

Category	No.	Item	Specification and Quantity
Groundwater Development	1	Drilling Rig	100 m or Deeper, 4WD Vehicle, DTH Hammer and Mud Drilling
	2	Hammers and Bits	Appropriate Diameter
	3	Temporary Casings	for 60 m
	4	Drilling Tools	
	5	Air Compressor	4WD Vehicle
	6	Truck with Crane	4WD Vehicle
	7	Transportable Workshop	Vehicle type, Necessary Accessaries
	8	Tools for Pumping Test	
	9	GPS	
	10	Electric Logging Device	
	11	Electric Prospecting Device	
	12	Training（Technical support）	For Operation and Maintenance of the Listed Equipment
NRW Reduction	1	Pipe Installation Equipment	
	2	Leak Management Equipment	
	3	Management and Inspection Equipment	
	4	Dredging Equipment	

The contents of the official request submitted from MAIWD in October 2017 are as follows.

Table 2 : Request for equipment procurement from Malawian side (the final version)

Category		No.	Item	No.	Item
Groundwater Development		1	Drilling Rig	9	Data Logger
		2	Air Compressor	10	Water Gauge
		3	Truck with Crane	11	Depth Gaufe
		4	Drilling Hammer and Bits	12	Borehole Camera
		5	Casings	13	Electric Logging Device
		6	Transportable Workshop	14	Electric Prospecting Device
		7	Tools for Pumping Test	15	Drilling Tools
		8	GPS		
NRW Reduction	Pipe Installation	1	Pipe Drilling Tools	9	Tools
		2	Clamp Saddle	10	Compacter
		3	Pipe Threading Tools	11	Truck with Crane
		4	Butte Welding Machine	12	Engine Pump
		5	Pipe Cutter	13	Lighting Gear
		6	Lifting Tools	14	Small Excavator
		7	Small Generator	15	Pipe Repair Clamp and Dressor Joint
		8	Electric Welding machine		
	Leak Management	1	Leak Detection Tools	5	Pipeline Detector
		2	Portable Ultrasonic Flow Meter	6	Portable GPS
		3	Water Pressure Meter	7	Pressure Reduce Valves
		4	Leak Sound Detection Bar		
	Management and Inspection	1	Accuracy Tester of Water Meter	3	Pickup tTuck
		2	Pressure Gauge for Water Faucet	4	Motor Cycle
Soft Component		For Operation and Maintenance of the Listed Equipment			

3. Outline of the Survey Results and Contents of the Project

3-1 Outline of the Survey Results

(1) Schedule of the Survey

The Survey was conducted from July to August 2017. Scope of the Project, selection and design of procurement equipment and estimated cost for the Project were examined, following analysis in Japan. The second visit to Malawi for explaining the outline design plan was carried out in December 2017.

(2) Relevance of Equipment Procurement

1) Groundwater Development

Malawi Rural Water Supply Investment Plan was established in April 2015 in order to improve the access rate of rural water supply to 90% by 2020, based on Malawi Vision 2020 and Water Sector Investment Plan 2007 and 2012. The procured equipment for groundwater development shall be equipment to promote water resource development and rehabilitation of boreholes such as rigs for deep and shallow aquifers; and service rigs in order to achieve the high level of rural water supply. The relevance, effectiveness and sustainability of the procurement for the Project were examined, based on the following five criteria agreed with MAIWD and LWB at the time of the Minutes of Discussions.

◆Policy, Strategy and Plan

As requirements to procure rigs for deep aquifers, MAIWD needs to clearly have a high priority on

groundwater development at the depth of 100 m or deeper under their policies and strategies. In addition, they need to have the groundwater development plan that identifies the specific target areas and numbers of projects based on their policies and strategies. These requirements are examined through the Survey; it is confirmed that specific descriptions regarding the high priority of groundwater development of 100 m or deeper were not yet incorporated into overall plans. Accordingly, development plans were not described in enough detail to include target areas and depth of deep groundwater development. Although MAIWD recognized the necessity of deep groundwater development, they are not able to drill deeper than 100 m owing to a lack of rigs capable of dealing with deep aquifers. Thus, MAIWD could not incorporate deep groundwater development into either overall plans or development plans at present. On the other hand, the surrounding countries such as Zambia, Mozambique and Tanzania, develop groundwater at a depth of 100 m or deeper; MAIWD is able to procure rigs for deep aquifers from the neighboring countries for the purpose of planning or developing deep groundwater. Thus, it is presumed that deep groundwater development has not been promoted in Malawi due not only to the lack of equipment but also to the demand for deep groundwater development and cost for construction.

Meanwhile, MAIWD plans to implement the Level 2 water supply facilities (reticulated groundwater source system) at 74 market centers, selected based on the four criteria (the situation of water supply system, groundwater source availability, aquifer distribution and water quality, and the demand for reticulated groundwater source system) in Malawi Rural Water Supply Investment Plan. Out of 74 market centers, 32 market centers were selected to be developed first, due to the size of the population and current water supply condition. During phase I (2014~2020), implementation of 61 and 54 boreholes are proposed by 2017 and 2020 respectively. African Development Bank (AfDB) is working on Water Supply and Sanitation Project to develop seven market centers. This project is operated at Nathenje, Kaisya, Nsalu, Nkando, Malosa, Ntaja and Nsanama and co-financed by Australian Agency for International Development (current Department of Foreign Affairs and Trade: DFAT) under National Water Development Program. These targeted locations are different from the 32 market centers described above.

Malawi Rural Water Supply Investment Plan refers to the rehabilitation of a total of 5,593 existing boreholes, though it does not describe specific target boreholes, years and priorities. The plan is considered as indefinite because the figure was not estimated based on the actual conditions of boreholes. MAIWD examined the number of borehole required rehabilitation through the assumption that approximately 75 % (5,593 boreholes) of the total number of inactive boreholes (7,462 boreholes) reported from each District is repairable. The priority of rehabilitated locations is only mentioned as 21 Districts, where the rate of inactive boreholes exceeds 10%. Under the policy, the maintenance and rehabilitation of boreholes are principally operated at the community level; MAIWD is assigned for a large-scale rehabilitation. However, their services are for a fee and thus, NGOs often take charge of large-scale rehabilitation works because of their lower-cost services and close relations with communities.

◆ Aquifer (Capacity of Development)

Groundwater storage availability including the target depth are examined through the Project by

verifying the presence of aquifers based on the existing hydrogeological data as the Project does not include exploratory drilling or geophysical prospecting. The Hydrogeological Survey (geophysical prospecting) conducted between 2014 and 2015 confirmed the possibility of the existence of aquifers at a depth of 100 to 200 m in some areas. However, it is only an estimation based on analysis results of the geophysical prospecting and it could not be verified with the data on drilling and pumping test at a depth of 100 m or deeper in Malawi.

On the other hand, the Hydrogeological Survey has carried out the exploratory drillings and pumping tests up to a depth of 100m and it found that yields of 5.0 to 10.0 ℓ/s or more can be secured at 12 sites in Malawi and the water-level falls within 22 m or less. The results indicate that the capacity of groundwater storage at shallow aquifers in these areas is high. Enhancing the yields of one borehole can lead to the reduction of the number of boreholes, and still enable attainment of the necessary amount of water. Reduction of the number of boreholes makes operation and maintenance easier and contributes to suppression of operation cost (water fees of beneficiary). It is required to finish a borehole with a larger diameter (6 to 8 inches for inner diameter) rather than normal diameter (4 inches), and install a submersible pump with a large outside-diameter with higher capacity of pumping in order to reduce the number of boreholes. However, Malawi does not have large diameter bits nor are the existing rigs capable of large-diameter bits at present.

◆ Operation and Maintenance Structure of Equipment Management

Technical skills, financial capability and supply system of spare parts are examined, assuming the equipment is procured, since there are no records in operation and maintenance of rigs that are capable of drilling more than 100 m in Malawi.

MAIWD does not have experience drilling more than 100 m. However, they are evaluated to have a capacity of drilling deep aquifers through acquiring the knowledge of deep drilling because the borehole drilling has been operated directly by MAIWD, which accounts for 34 to 108 boreholes per year in the past few years. Furthermore, it can be evaluated that there is no budgeting problem, considering that a fixed amount of funds are secured every year, even though MAIWD's budget for groundwater development is completely dependent on the Borehole Construction and Groundwater Management Fund (the Borehole Fund). The source of the Borehole Fund is the construction fee from the customers, who request the borehole construction. MAIWD pays 5 % of the fee to the Ministry of Finance and properly reduces the remaining 95% in order to allot the fee for the construction of another borehole, repairs of equipment and purchase of spare parts as well as the construction for boreholes requested by the customers. It is judged that MAIWD does not have any financial issues as they secure a fixed amount of Borehole Fund every year and raise the Fund for operation and maintenance of the equipment.

In addition, MAIWD is judged to have no issues for the supply chain although specified spare parts of drilling equipment is not available in Malawi. Indeed, they have experienced purchasing spare parts from Japan and South Africa through the Borehole Fund.

◆ Operation and Maintenance Structure of Facility Management

Generally, additional equipment, such as an electric pump, is required to install with boreholes deeper

than 100 m because the capacity of deeper boreholes exceed that of hand pumps owing to the yield and pump head. The status of operation and maintenance is examined through the Project to confirm the following procurement requirement for sustainable operation and maintenance of boreholes: well establishment of technical skills; financial capacity; supply chain of spare parts (pumps and boreholes); and organization, institutions and policies for sustainable.

Considering the population for water supply; the cost for operation and maintenance; and technical difficulties, deep boreholes shall be implemented as Level 2 water supply facilities (submersible pump) at market center, though it is not referred to in the policy. In that case, under the jurisdiction of Urban Water Divisions at District Water Development Offices, Regional Water Boards (North, Central and South) are responsible for maintenance. Furthermore, they are also in charge of maintenance of shallow groundwater development at market centers under the jurisdiction of Urban Water Divisions at District Water Development Offices. They have sufficient experience of maintenance as they have maintained Level 2 facilities for shallow groundwater at several market centers on an independent accounting system.

In addition, 42 of the water supply facilities operated in the community are Level 2 facilities with shallow groundwater. These are operated by Water Users Association (WUA) under the jurisdiction of Piped Water Divisions at District Water Development Offices. However, compared with hand pump facilities, water supply facilities with an electric pump for deeper groundwater is more difficult to operate and repair. It also requires additional management and repair for the equipment such as reservoirs, distribution pipes and public faucet as well as sustainable electric power. Thus, concern remains regarding the operation and maintenance at community level due to the lack of experience in operating Level 2 facilities.

Level 1 water supply facilities (borehole with hand pump) are operated and maintained by Village Health Water Committee (VHWC), and Water Point Committee (WPC). However, when a community cannot respond to a break down, a private repair agent for water facilities, called Area Mechanic, provides a repair service for a fee. Under this system, CBM coordinators and Water Monitoring Assistant provide technical guidance on maintenance under the supervision of Department of Water Supply at MAIWD. Both MAIWD and NGOs are responsible for a large-scale rehabilitation; however, as mentioned above, NGOs often take charge of the rehabilitation work because of their close relations with communities.

◆ Capability of Drilling (Including Private Company)

Since the urgent need shall be recognized for the Grant Aid Project as a prerequisite, the drilling capability in Malawi including private companies is examined.

It is evaluated that MAIWD is currently capable of drilling to a depth of 60 to 80 m at most, due to the aged deterioration of equipment. Although there are approximately 20 private drilling companies in Malawi, none of them have a drilling capacity deeper than 100 m. In other words, neither MAIWD nor private drilling companies in Malawi have a drilling capacity deeper than 100 m in Malawi. Furthermore, the maximum diameter of drill bits, which MAIWD and private drilling companies own, is 4 inches and there are no bits with a diameter of more than 4 inches in Malawi.

As mentioned above, there is no significant difference in drilling capacity between MAIWD and private companies and thus, certain division of work, according to the borehole specifications such as depth and diameter, were not found.

With regard to a method of ordering borehole drilling in Malawi, it is often the case that MAIWD and private drilling companies participate in general competitive bidding. When placing an order with MAIWD, it is necessary to pre-pay the expense to the Borehole Fund. On the other hand, in the case of placing an ordering with private drilling companies, contingent fee system (no compensation will be paid if drilling does not yield any water) is adopted as Malawi's commercial practice. Thus, it is often decided whether to make general competitive bidding or placing an order to MAIWD, based on the purpose of borehole drilling, difficulty (success rate), budget source and budget amount. Hence, MAIWD does not have superiority in general competitive bidding for shallow groundwater development.

The results of evaluation based on the above consideration are as follows.

Table 3 : Result of evaluation for assumed procurement equipment

	Drilling Rig (Deep Aquifers, Large Diameter)	Drilling Rig (Shallow Aquifers, Large Diameter)	Service Rig (Maintenance Vehicle)
① Policy, Strategy and Plan	"Negative" Intend to develop deep aquifers, however concrete development plans exist for only shallow aquifers	"Middle" Development plan for shallow aquifers exists for market centers, however a high feasibility of drilling large-diameter boreholes found at only three sites	"Middle" Borehole rehabilitation in rural areas done by communities, while market centers done by Water Boards (MAIWD is for large-scale rehabilitation)
② Aquifer (Capacity of Development)	"Middle" Possibility of deep aquifers at some areas, however results cannot be verified without drilling records	"Positive" High groundwater storage found at shallow aquifers	
③ O&M Structure of Equipment Management	"Positive" MAIWD acquired equipment operation and experienced purchasing spare parts from foreign countries.	"Positive" -ditto-	"Positive" -ditto-
④ O&M Structure of Facility Management	"Middle" Communities have less experience of O&M for deep boreholes, while Water Boards has sufficient experiences for market centers.	"Positive" MAIWD has sufficient experiences in operation and maintenance of shallow boreholes.	"Middle" Borehole rehabilitation in rural areas done by communities, while market centers done by Water Boards (MAIWD is for support)
⑤ Capability of Drilling (including Private company)	"Positive" Neither MAIWD nor private drilling companies have drilling capacity deeper than 100m	"Positive" Neither MAIWD nor private drilling companies have drilling capacity of 8inch-diameter.	"Middle" Existing heavy machinary can fix and rehabilitate boreholes.
Evaluation	Low priority	Middle priority	Low priority

Remark: "Positive", "Middle" and "Negative" in the table indicate the evaluation results of each criteria.

Drilling Rigs for Deep Aquifers

MAIWD plans to construct 1 to 7 boreholes of 40 to 55 m at each of the 32 market centers in Malawi Rural Water Supply Investment Plan; however, specific descriptions of deep groundwater development were not incorporated into the plan yet, and it is still under progress at present. In addition, as mentioned above, neither other overall plans nor development plans make mention of deep groundwater development.

Furthermore, the result of geophysical prospecting confirmed the possibility of aquifers at a depth of 100 – 200 m in some areas. Nevertheless, it could not be verified because there are no records of drilling deep aquifers (underground geological data deeper than 100 m).

Thus, it is considered as premature to procure the rig with a large-diameter for deep aquifers because a plan

respecting the use of rigs is still in preparation and concern remains about whether it will be fully utilized if it is procured.

Drilling Rigs for Shallow Aquifers

As mentioned above, MAIWD plans to construct 1 to 7 boreholes of 40 to 55 m at each of the 32 market centers in Malawi Rural Water Supply Investment Plan. As for shallow groundwater development, the overall plan exists. Furthermore, the geophysical prospecting conducted by MAIWD, carried out the pumping test at 41 sites nationwide and three of these sites corresponded with the location of market centers. Based on evaluation of pumping test results, these three sites are identified to have a capacity of groundwater storage at shallow aquifers, which means they can endure water-level drops while using submersible pumps.

Procurement of the rig for shallow aquifers with large diameter may contribute to the reduction of operation cost (electricity fee) as well as improvement of operation and maintenance because it enables to enlarge boreholes and use a large-scale submersible pump at market centers, where the construction of several boreholes are planned.

In addition, three out of four rigs owned by MAIWD have exceeded their service life. The service life for the equipment is generally five years and thus the procurement of drilling equipment is important in terms of the renewal of equipment.

However, currently three sites out of the 32 market centers have a possibility of developing shallow boreholes with large diameter and it is hard to secure the specific aims in other areas. Thus, the cost effectiveness of equipment procurement is judged as insignificant; hence the rig for shallow aquifers is excluded from the procurement.

Service Rigs

Under the operation and maintenance system for water supply facilities, local communities are responsible for rehabilitation of boreholes at rural areas, while Regional Water Board is in charge at market centers. The role of MAIWD for operation and maintenance is only a large-scale rehabilitation of boreholes. Thus, it is considered that service rigs are not guaranteed to be used properly and continuously. Furthermore, both MAIWD and private companies are able to utilize existing rigs for borehole rehabilitation.

Conclusion

The relevance of procurement is examined for equipment of groundwater development (rigs for deep/shallow aquifers and service rigs). As a result, further investigation is required to determine the relevance of procurement; however, the present situation is judged not to meet the criteria agreed at the start of the Survey. Thus, the equipment of groundwater development is excluded from the scope of the Project.

However, the possibility of developing new water resource in Malawi will expand when development plans for groundwater, particularly for deep aquifers or shallow aquifers with large diameter, are put into concrete shape.

2) NRW Reduction

LWB, which has jurisdiction over the water supply in Lilongwe City, placed a high priority on making maximum use of the limited water resource of Lilongwe River, located downstream of Kamuzu Dam, in line with MGDS II. LWB established the Strategic Plan to make the most use of water resources and clarify four

(4) strategic issues as follows:

- Unreliable Water Supply Service
- Weak Customer Relations
- Limited Financial Capacity for Infrastructure Development
- Inadequate Institutional Capacity

"Simplified Water Supply Plan in Lilongwe City" was established to deal with above strategic issues by the consultation between LWB and Survey Team during the Survey. As a result, the measures for improving the water supply situation are organized as (1) Water Resource Development, (2) Expansion and Rehabilitation of Pipes (3) Strengthening Financial Capacity and (4) NRW Reduction.

Table 4 : Relevance between strategic issues and measures for improving the water supply situation

Measures for Improving the Water Supply Situation (Draft)	Four Strategic Issues			
	Unreliable Water Supply Service	Weak Customer Relations	Limited Financial Capacity for Infrastructure Dev.	Inadequate Institutional Capacity
①Water Resource Development	○	○	○	
②Expansion and Rehabilitation of Pipes	○	○	○	
③Strengthening Financial Capacity	○	○	○	
④NRW Reduction	○	○	○	○

The progress of measures and detailed activities to improve water supply situation in Lilongwe City are as follows.

Table 5 : The progress of measures and detailed activities

Policy (Draft)	Concrete Initiatives	Implementing Entity
①Water Resource Development	Renovation and Raising of Kamuzu Dam	EIB
	New Construction of Water Treatment Plant	World Vank
②Expansion and Rehabilitation of Pipes	Expansion and Rehabilitation of Main Water Supply	EIB, World Bank
③Strengthening Financial Capacity	Stable Water Fee Collection (Installation of Prepaid Meter)	LWB
④NRW Reduction	Separation by DMA Establishment	LWB, Vitens
	Training of Caretakers	Vitens
	Improvement of Working Quality	LWB
	Procurement of Countermeasure Equipment	None

① Water Resource Development

Expansion of water resource amount leads to an increase in water amount supplied to Lilongwe and thus, it can greatly contribute to the improvement of water utilities and reduction of NRW. LWB sets the "Renovation and Raising of Kamuzu Dam I" and "Maintenance of Water Treatment Plant (Treatment Works III)" as a medium-term target in the "Infrastructure Investment Plan". The Project for Kamuzu

Dam aims to increase water resource capacity by raising the retaining wall (H=5.0m approx.) of Kamuzu I (4.5 to 19.6 Mm^3) and rehabilitation of Kamuzu II (19.8 Mm^3), planned by EIB.

LWB is making progress on concrete measures regarding water resource development through the support of other donors.

② Expansion and Rehabilitation of Pipes

According to the GIS data, the transmission and distribution pipes throughout Lilongwe City have a total extension of 1,750 km. However, pipes are damaged by water hammer pressure caused by aging or stoppage of water supply at the time of power outage and thus, leakage and suspension of water supply frequently occur. Moreover, asbestos pipes occupy 26.5% (466 km) of the total of the transmission and distribution pipes, which is one of the causes of the insufficient resistance of pipes.

LWB makes the renewal of asbestos pipes the top priority of pipe rehabilitation. Currently, under the support of EIB, the rehabilitation project has been undertaken to replace 18.8 km of the existing asbestos pipes with large-diameter ductile cast iron pipes, in accordance with water demand prediction in 2023.
In addition, LWB plans to rehabilitate 41 km of asbestos pipes with the support of WB. The existing asbestos pipes totaling 59.6 m will be renewed through these projects, although 406 km of these pipes remain untouched. The Survey Team confirmed that the rehabilitation of these existing pipes will be promoted mainly by WB and detailed survey will be conducted to design duct extension and pipe diameter by consultants hired by WB in 2018.

Table 6 : Rehabilitation plan for existing asbestos pipes

Unit: km

Zone	Existing Pipes	Rehabilitation Plan			Remaining
		EIB	World Bank*	Total	
North	160.3	8.3	13.1	21.4	138.9
Central	154.2	3.0	12.9	15.9	138.4
South	151.6	7.6	14.9	22.5	129.1
Total	466.1	18.8	40.8	59.6	406.4

* Target Value Before Detailed Design

Source: LWB documents

LWB is also improving its pipe repair system, based on the NRW Reduction Strategy, to reduce the physical loss caused by leakage and pipe bursts. The LWB headquarters is equipped with 1,000 polyvinyl chloride pipes (PVC) and 6,000 water flow meters, and Warehouse Section in LWB manages the usage status and replenish their stocks appropriately. In FY 2017/18, US 1.5 million dollars were appropriated to repair pipes; and LWB is arranging a system to supply and stock pipe materials in order to respond to emergency repairing.

LWB is making progress on concrete measures regarding expansion and rehabilitation of pipes by other donors' support and self-help efforts.

③ Strengthening Financial Capacity

LWB is working on stabilizing the collection of water fee to strengthen its financial capacity, and they plan to install 23,500 pieces of prepaid water meters by 2020 as a measure. At present, it is under the first phase when procurement of 5,000 pieces (1,250 for large users and 3,750 for ordinary customers) is

in progress with its own budget (currently in the stage of bidding). In the second phase, 18,500 pieces (3,500 for commercial and corporate customers and 15,000 for ordinary customers) will be procured under the support of EIB.

LWB is making progress on concrete measures to strengthen financial capacity by other donors' support and self-help efforts.

④ NRW Reduction

LWB shall grasp the amount of NRW accurately to work on its reduction. In Lilongwe, total water supply area is isolated into 106 DMA (District Metered Areas) by LWB and Vitens Evides International (VEI). LWB Network Section and GIS Section have updated (GIS databased) the information on existing pipes and valves accordingly, and they have established a system to grasp the status of existing facilities and information on water pressure and flow rate by using pipe-network analysis model (EPANET 2).

Human resource development plays a significant role in NRW reduction and thus, the Technical Cooperation Project of NRW is being implemented in the north region with the aim of fostering caretakers through VEI. On the other hand, in the south region, JICA plans to implement the Technical Cooperation Project of NRW for the purpose of improving a capacity to develop a plan for NRW reduction and technical skills such as installing, repairing, meter reading, leak detection, customer response and public relations.

In addition, LWB has recognized an improvement of work quality as one of the pillars of NRW reduction and hence, they are pursuing the enhancement of quality management through acquiring ISO 9001 and the improvement of customer satisfaction by establishing a customer correspondence system.

Despite the situation that LWB is actively working on NRW reduction and other donors are supporting the activities, the effect of NRW reduction is limited. The limitation results from the lack of equipment for pipe installation; leak management; and management and inspection, in other words, lack of quantity and grade of equipment for NRW reduction. Moreover, it is one of the factor hindering the effectiveness of LWB that their staff members could only deal with issues (pipe exchange, repair and inspection) on a temporary basis because the necessary equipment is not in place.

Based on the above survey results, the equipment procurement for NRW reduction is determined as appropriate. LWB had requested the equipment for pipe installation; leak management; management and inspection; and dredging in the Minutes of Discussions dated 20th of July, 2017. The relevance, effectiveness and sustainability of each component were examined based on the following items.

- To be identified as prioritized equipment in Simplified Water Supply Plan in Lilongwe City, prepared by the Survey
- To Contribute rolling out the output of the JICA Technical Cooperation Project of NRW
- To Ensure immediate use in the field
- To be agreed with stakeholders to use and have no negative impacts
- To be not affected by contents and schedule of other donors' projects, which either in progress or intend to be implemented

The examination and evaluation results of each equipment component are as follows.

◆ Pipe Installation Equipment

Poor connection of pipes (construction failure) and aged pipes are a major cause of water leakage and it is urgent to connect and repair pipes properly. The procurement of equipment greatly contributes to reduction of NRW.

◆ Leak Management Equipment

Underground leakage is difficult to detect by visual inspection and thus, water utilities tend to be unaware of its existence over a long period. Procurement and utilization of leak management equipment will greatly contribute to the discovery and reduction of underground leakage.

◆ Management and Inspection Equipment

Routine patrol, inspection and communication with customers are necessary as mentioned in the Strategic Plan 2015-2020, to reduce accidents (pipe bursts or water theft) in water facilities, especially pipelines. However, the total length of the city pipe network, managed by LWB, is approximately 1,750 km and thus, LWB staff members end up spending a lot of time doing daily work such as repairing and expanding pipes. They do not have enough time to organize and analyze various work information and formulate countermeasures. Therefore, improving the quality management through management and inspection equipment for the facility management greatly contributes to the reduction of NRW rate.

◆ Dredging Equipment (Low Priority)

Dredging equipment is used to dredge the area near the water intake at the water treatment plant to increase the amount of water intake for effective use of water resource (Lilongwe River), as proposed in MGDS II. The equipment is for water resource development although it is acknowledged as an effective countermeasure against NRW because the increased amount of water intake results in increased revenue earning water. Additionally, dredging work is carried out about once or twice a year and it can be done with the heavy machinery (backhoe) owned by LWB. Therefore, the priority of procurement of dredging equipment is evaluated as low.

Furthermore, the relevance, effectiveness and sustainability of a back-up generator were evaluated because they were additionally requested because of the Survey and consultations with the LWB.

◆ Back-up Generator Equipment

Water hammer pressure occurs when the pressure difference inside the water distribution pipe changes greatly due to suspension of water supply at the time of power outage. It damages the aged distribution pipes and contributes to leakage, results in NRW. Furthermore, during the suspension of water supply at the time of power outage, contaminated water flows in from negative pressure pipes where leakage occurs, and subsequently NRW increases due to the removal of contaminated water and pipe cleaning. Large-scale inflow of contaminated water caused by power outage occurred during the Survey, became a significant social issue in Malawi. Thus, ensuring continuous operation even at the time of power outage is effective for protecting pipe network. Maintaining the emergency power supply at the main water supply facilities will greatly contribute to the reduction of NRW.

The equipment for pipe installation; leak management; management and inspection; dredging; and back-up generator were evaluated, as shown in the table below, based on the following items.

- To be identified as prioritized equipment in Simplified Water Supply Plan in Lilongwe City
- To Contribute rolling out the output of the JICA Technical Cooperation Project of NRW
- To Ensure immediate use in the field
- To have no negative impacts
- To be not affected by contents and schedule of other donors' projects, which either in progress or intend to be implemented

Table 7 : Evaluation of component for NRW reduction equipment

Items to be Considered for Appropriateness , Effectiveness and Sustainability of Procurement	Component of NRW Reduction Equipment				
	Pipe Installation	Leak Management	Management and Inspection	Dredging	Back-up Generator
Prioritized Equipment in Simplified Water Supply Plan in Lilongwe City	○	○	○	×	○
Contribution to the Output of the JICA Technical Cooperation Project of NRW	○	○	○	○	○
Immediate Use in the Field	○	○	○	×	○
No Negative Impacts by the Project	○	○	○	○	○
No Impacts by Other Donors' Projects	○	○	○	○	○

Based on the above evaluations, the Project will procure the equipment for pipe installation; leak management; management and inspection; and back-up generator. The purpose of utilizing the equipment is as follows.

Table 8 : The purpose of utilizing the equipment

Expected Cause of NRW	Components	Purpose of equipment procurement
Construction Failure of Pipe Connection	Pipe Installation	Improvement of Workability
Aged Pipes		Replacing of Aged Pipes
Invisibility of Lakage Point	Leak Management	Visualization of Leakage Point
Misreading of Water Meter	Management and Inspection	Correction of Erroe in Meter Reading
Pipe Brekage due to Power Outage	Back-up Generator	Protection of Pipe Network

(3) Outline Design Drawing

1) Equipment Suppliers

Daily operation of NRW reduction measures (pipe installation, operation and maintenance, etc.,) is performed by a work team composed of a caretaker as a leader, plumbers, assistant plumbers and common labours at each LWB Zone Offices (North, Central and South). The equipment for the Project will be procured for these work teams as well as Zone Offices.

Currently, Network Section has gathered flow measurement and pipeline position information of all pipe networks in Lilongwe City, and the information has been databased by GIS Section. LWB established NRW Reduction Section, consisting of finance, engineering and monitoring and evaluation, at the end of 2017, and these staff member will carry out data management of NRW reduction and formulate policies at each Zone Office. The work records and data obtained through the procured equipment will be managd by the Section in

the future.

2) Equipment Planning

Relevance, component and quantity of each equipment to be procured were examined regarding the equipment for pipe installation; leak management; management and inspection; and back-up generator. The water flow meter and the prepaid water meter, which was assumed to be procured before the Survey, were excluded from the equipment procurement due to the following reasons.

◆Water Flow Meter

A water flow meter shall be installed at the inflow point of the district-metered area (DMA) in Lilongwe City to grasp the water consumption of each DMA. However, the separation (DMA) has been established at 106 locations by LWB in August 2017, and the installation of water flow meters were almost completed. Hence, it is excluded from the scope of the Project.

◆Prepaid Water Meter

Prepaid water meters shall be installed to prevent unpaid water charges and alleviate workloads on meter readers. Installation has been already planned for government agencies and large water users initially, and it will be deployed to every door sequentially. LWB has posted a budget of 2.7 million USD in FY 2017/18 and they have procured and installed 5,000 pieces (1,250 pieces for large water users and 3,750 pieces for general customers) in August 2017. Thus, it is excluded from the scope of the Project.

The equipment was divided into “occupied equipment for each work team” and “shared equipment”, and the arrangement and quantity of equipment is examined, based on the frequency and purpose of use for each work item (pipe installation; leak management; management and inspection). It is noted that the Project does not post the quantity of equipment, which will be procured by the JICA Technical Cooperation Project of NRW.

(4) Contents of the Project

The equipment to be procured in the Project is as follows. It is composed of equipment for pipe installation; leak management: management and inspection; and back-up generators.

Table 9 : List of equipment to be procured for the Project

Component	No.	Item	Quantity	Procurement breakdown
Pipe Installation	101	Pipe Drilling Tools	11 Units	North・Central×4 Units、South×3 Units
	103	Pipe Threading Tool	12 Units	North・Central・South×4 Units
	105	Pipe Cutter	6 Units	North・Central・South×2 Units
	106	Lifting Tools		
		●Chain Hoist	12 Units	North・Central・South×4 Units
		●Lever Hoist	12 Units	North・Central・South×4 Units
	107	Small Generator	11 Units	North・Central×4 Units、South×3 Units
	108	Electric Welding Machine	3 Units	North・Central・South×1 Unit
	109	Tools	12 Sets	North・Central・South×4 Sets
	110	Compactor		
		●Plate Compactor	12 Units	North・Central・South×4 Units
		●Hand Compactor	12 Units	North・Central・South×4 Units
	111	Small Excavator	2 Units	North・Central×1 Unit
	112	Truck with Crane	3 Units	North・Central・South×1 Unit
	113	Engine Pump	6 Sets	North・Central・South×2 Sets
	114	Lighting Gear		
		●Generator Integrated Lighting Gear	3 Units	North・Central・South×1 Unit
		●Lighting Gear *	5 Units	North・Central×2 Units、South×1 Unit
	115	Pipe Repair Clamp and Dresser Joint		
		●Pipe Repair Clamp	4,179 Pieces	ND63×1944、ND110×1446、ND160×789
		●Dresser Joint	3,345 Pieces	ND63×1557、ND110×1158、ND160×630
	117	Water Pressure Tester	3 Sets	North・Central・South×1 Set
	119	Transporter Truck for Small Excavator	3 Units	North・Central・South×1 Unit
Leak Management	201	Leak Detection Tool		
		●Correlation Formula	2 Units	North・Central×1 Unit
		●Sound Hearing	5 Units	North・Central×1 Unit、South×3 Units
	203	Pressure Meter With Data Logger	4 Units	North・Central×2 Units
	204	Leak Sound Detection Bar		
		●Analog type	11 Units	North・Central×4 Units、South×3 Units
		●Digital type	11 Units	North・Central×4 Units、South×3 Units
	205	Pipeline Detector	2 Units	North・Central×1 Unit
Management and Inspection	301	Accuracy Tester of Water Meter	6 Units	North・Central・South×2 Units
	302	Pressure Gauge for Water Faucet	20 Pieces	North・Central×10 Pieces
	304	Motorcycle	6 Units	North・Central・South×2 Units
Back-up Generator	501	Back Up Generator	1 Unit	Mwenda Booster Pump Station (South) ×1 Unit

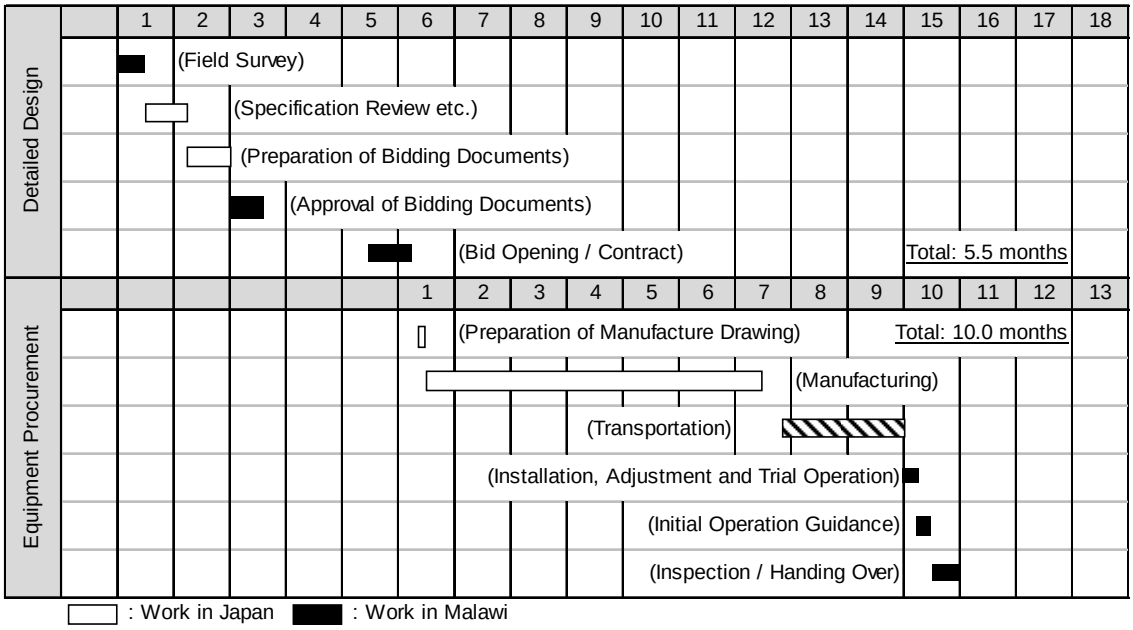
*The Project will procure a year's worth of consumable goods for procured equipment.

4. Implementation Schedule and Cost Estimation for the Project

(1) Implementation Schedule for the Project

The implementation schedule for the Project is as follows.

Table 10 : Implementation Schedule for the Project



(2) Project Cost

The project cost shall be bome by Malawian side required to implement the Project is 18,712 USD.

5. Project Evaluation

(1) Relevance

"National Water Resource Master Plan" established through "Project for National Water Resources Master Plan Resources in the Republic of Malawi" (2012-2014) specifies an improvement of water supply in Lilongwe City as the top-priority. In particular, NRW reduction is referred to as the highest-priority activity to improve water use efficiency of existing water resources. Moreover, LWB has set the goal to reduce NRW rate (36%) in 2015 to 28% in 2020 in the Strategic Plan. Therefore, the Project is in accordance with development plans in Malawi.

Additionally, "Country Assistance Policy for the Republic of Malawi" (April 2012) stated by the Government of Japan addresses "Improvement of basic social services" as priority areas. "Safe and Stable Water Supply Programme" is operated to tackle the priority area, and it aims to improve stable water supply through rehabilitation of facilities and enhancement of maintenance system. On that account, the Project corresponds to development cooperation policy of the Government of Japan to Malawi.

Indeed, LWB is the direct beneficiary of the Project; however citizens in Lilongwe including poor group will also be benefited by the Project since universal and equal access to safe and affordable drinking water to them will be realized thorough improvement of NRW management efficiency, reduction of NRW and improvement of the water supply service in Lilongwe.

Therefore, implementation of the Project is in line with Japanese cooperation policies and rolling plan as well as development plans and policies in Malawi. Maintenance of procured equipment for NRW reduction will lead to improvement of water use efficiency and water supply service, and it promotes Sustainable Development Goals 6 ("Ensure availability and sustainable management of water and sanitation for all"). For these reasons, it is highly relevant to support the implementation of the Project.

(2) Effectiveness

1) Quantitative Impact

Utilization of equipment procured by the Project improves the work quality of pipe repairs and will lead to the reduction of working hours. Thus, it allows LWB to undertake leak detection, which was incapable of executing owing to lack of suitable equipment. Quantitative impact indicators are set as shown in Table 11 to confirm the level of achievement of the Project impact.

Table 11 : Quantitative impact indicators

Indicator			Reference Value (2017)	Target Value in 2022 (3 years after installation)
NRW Reduction	A Period of Repairing Pipes	(hour/place)	2.5	1.5
	Leakage Detection Distance	(km/year)	0	175

Quantitative impact indicator is calculated based on previous work contents of LWB. External conditions are considered not to have an impact on the calculation since additional operation expenses due to the activity for NRW reduction, which is mainly fuel cost for machinery, is minor. Level of achievement of the Project impact will be presumably identified through an inspection (monitoring) of work activities in forms of a weekly and monthly report, which will be recorded by work team and organized by Zone Offices.

2) Qualitative Impact

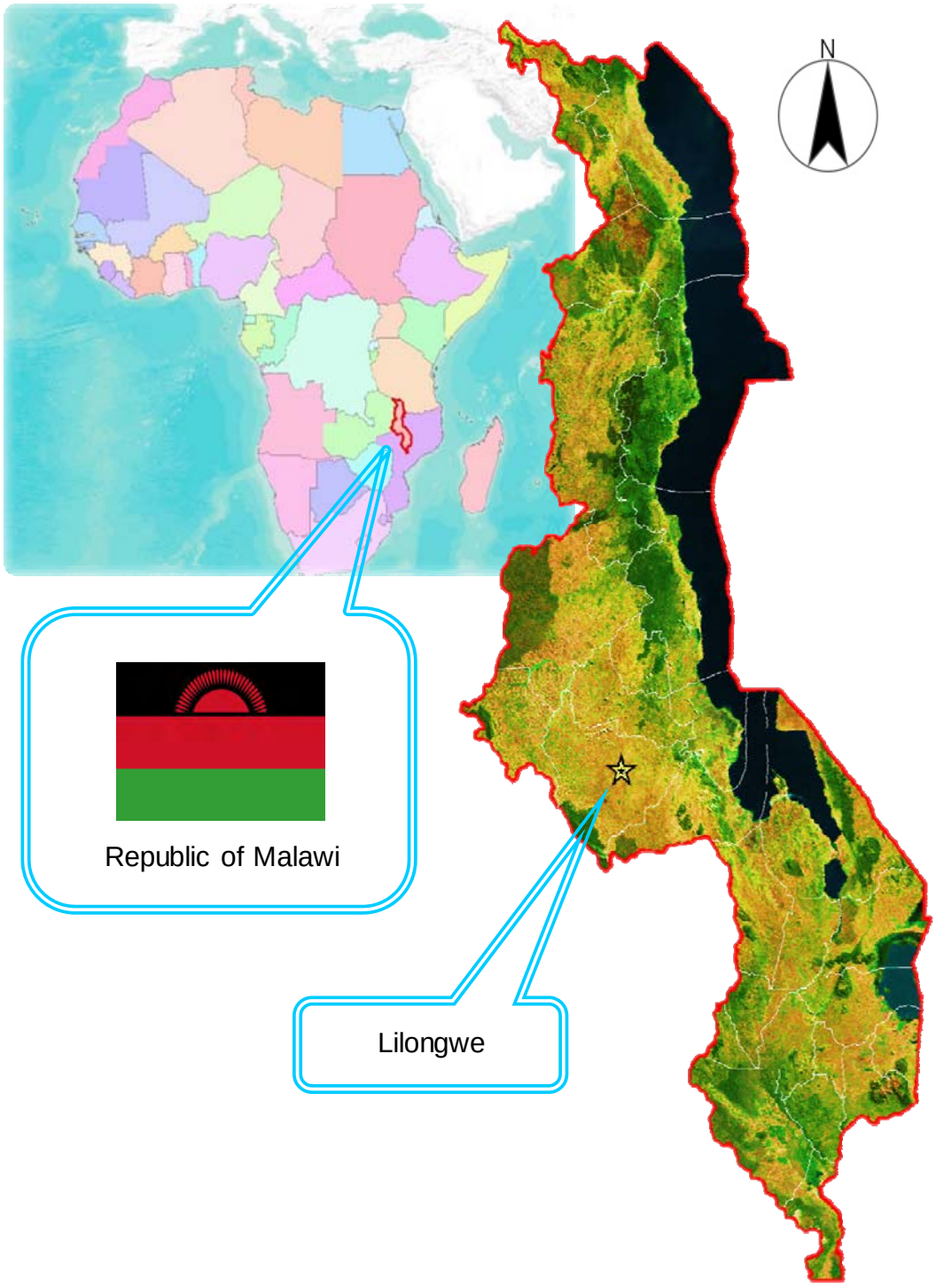
The expected qualitative impact by implementing the Project are as follows.

- ◆ Improvement of LWB's management (by reduction of overtime through improving work efficiency; and by increase of revenue due to increased revenue earning water)
- ◆ Improvement of satisfaction of LWB's customer (by improvement of reliability of LWB's work such as prompt pipe repairs)
- ◆ Water resource conservation in Lilongwe River basin (by reduction of excessive water intake from Lilongwe River due to leakage reduction)

The above has led to the conclusion that an implementation of the Project is highly relevant and effective.

Contents

［Appendices］



Preparatory Survey for the Project for Improvement of Groundwater Development and Non-Revenue Water Reduction in Malawi

Location Map

Photographs

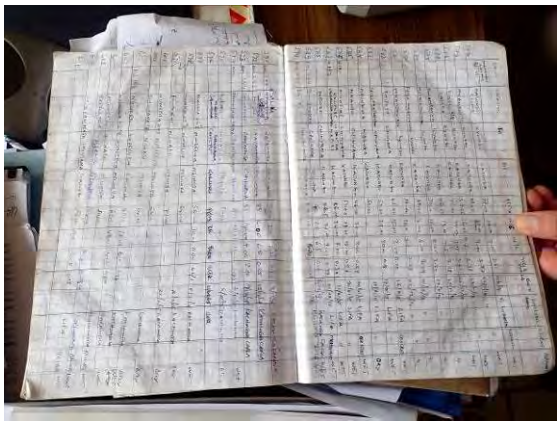
Inception Report Discussion
MAIWD HQ (Jul.17, 2017)

Provate Compnay Visiting
Chitsime Drilling Ltd. (Jul.18, 2017)

Inspection of MAIWD's owned Equipment
Central Zone Dev. Office (Jul.18, 2017)

Inspection of MAIWD's owned Equipment
Central Zone Dev. Office (Aug.4, 2017)

Inspection of Equipment Operation
Central Zone Dev. Office (Jul.26, 2017)



Drilling Record
MAIWD HQ (Aug.3, 2017)

Photographs

MAIWD's owned Rig
Central Zone Dev. Office (Jul.18, 2017)

MAIWD's owned Air Compressor
Central Zone Dev. Office (Jul.18, 2017)

MAIWD's owned Rig
Central Zone Dev. Office (Jul.18, 2017)

MAIWD's owned Geophysical Prospecting Equipment
MAIWD HQ (Jul.17, 2017)

MAIWD's owned Drilling Bit
Central Zone Dev. Office (Jul.18, 2017)

Vehicles discarded
Central Zone Dev. Office (Aug.4, 2017)

Photographs

Water Source
Kamzu Dam II (Aug.5, 2017)

Water Treatment Plant
LWB WTP (Jul.18, 2017)

Vulve Box
Lilongwe North Zone (Jul.26, 2017)

Pressure Reduce Valuve
Lilongwe North Zone (Jul.31, 2017)

Prepaid Water Meter
LWB HQ (Jul.22, 2017)

Test bench for Water Meter
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Photographs

Leakage Prevention Work
Lilingwe Sounth Zone (Jul.26, 2017)

Water Pressure Meter Exchange Work
Lilongwe South Zone (Jul.27, 2017)

LWB's owned Pipe Materials
LWB Stockyard (Jul.19, 2017)

LWB's owned Ultrasonic Flow Meter
LWB HQ (Aug.1, 2017)

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MAIWD HQ (Jul.20, 2017)

List of Tables and Figures

Abbreviations

Abbreviations	English
AC	Asbestos Cement
AfDB	Africa Development Bank
A/P	Authorization to Pay
B/A	Banking Arrangement
B/L	Bill of Lading
BS	British Standard
CBM	Community Based Management
CEO	Chief Executive Officer
DFAT	Department of Foreign Affairs and Trade
DIP	Ductile Cast Iron Pipe
DMA	District Meter Areas
DTH	Down The Hole
EIB	European Investment Bank
E/N	Exchange of Notes
FBT	Fringe Benefit Tax
G/A	Grant Agreement
GI	Galvanized Iron
GIS	Geographic Information System
GNI	Gross National Income
GPS	Global Positioning System
HDPE	High Density Polyethylene
HQ	Head Quarter
IDA	International Development Association
IMF	International Monetary Fund
INDC	Intended Nationally Determined Contributions
JICA	Japan International Cooperation Agency
LWB	Lilongwe Water Board
MAIWD	Ministry of Agriculture, Irrigation and Water Development
MGDS II	Malawi Growth and Development Strategy II
M/M	Man Month
MRA	Malawi Revenue Authority
MWK	Malawi Kwacha
N/A	Not Applicable
NBS	Northern Booster-pump Station

Abbreviations

Abbreviations	English
ND	Nominal Diameter
NGO	Non-Governmental Organization
PAYE	Pay as You Earn
PVC	Polyvinyl Chloride
RC	Reinforced Concrete
SCADA	Supervisory Control And Data Acquisition
SDGs	Sustainable Development Goals
TPIN	Tax Payer Index Number
USD	US Dollars
UNICEF	United Nations Children's Fund
VAT	Value Added Tax
VHWC	Village Health and Water Committee
WHT	Withholding Tax
WMA	Water Monitoring Assistant
WPC	Water Point Committee
WUA	Water Users Association

Chapter 1 Background of the Project

Chapter 1 Background of the Project

1-1 Background and Outline of the Grant Aid

The population growth rate of Lilongwe City, the capital of Malawi, is higher (4.3%) than that of national average (2.8%) according to the 1998 and 2008 census. Accordingly, the increasing demand for water is remarkable; it is about 135,000 m3/day that is far greater than the current water production volume (92,441 m3/day). In addition, the proportion of unbilled water (Non-Revenue Water) is as high as 37.9% (2016) due to water leakage caused by aging water distribution pipes, construction failures and misreading of water meters. These factors are negatively affecting the water demand and supply balance. Under such circumstances, the period of water supply has been decreasing over the past few years. It was 24 hours of water supply in 2010; however, it was 22 hours/day in 2011 and 20 hours/day in 2012. In particular, the shortage of water in 2016 was serious and water distribution in the City was forced to be cut to up to half of the usual amount between April and November 2011. As a result, suspension of water supply occurred three days a week and it had an extensive impact on civic life as well as on industries and administrative functions of the capital. Furthermore, apart from Lilongwe City, water shortages in rural areas are particularly serious, with 3 million people, which is equivalent to 30% of the population of village areas, unable to access safe drinking water.

The Government of Malawi (hereinafter referred to as the “GoM”) prioritized water resource development in the Malawi Growth and Development Strategy II (hereinafter referred to as “MGDS II”) in order to improve the above situation. Nevertheless, they have difficulty with securing funds for new water resource development in Lilongwe City and the development is not progressing as expected. Thus, Lilongwe Water Board (hereinafter referred to as “LWB”) is working on maximizing the existing water resources and reducing NRW rate to 28% by 2020 under the LWB Strategic Plan 2015-2020 (hereinafter referred to as “the Strategic Plan”). The effect, however, is limited.

On the other hand, Ministry of Agriculture, Irrigation and Water Development (hereinafter referred to as “MAIWD”) plans to develop shallow aquifers of groundwater in rural areas, where people are dependent on groundwater resources. Neither MAIWD nor private drilling companies own rigs capable of drilling 100 m or deeper and thus, the development is not progressing as expected.

In response to these situations, the GoM requested Grant Aid with regard to maintenance of equipment for groundwater development and NRW reduction. The contents of the request from GoM during the first Survey is as shown in the table below. The relevance of equipment procurement is examined according to contents of the table.

Table 1-1 : Request for equipment procurement from Malawian side (during the first Survey)

Category	No.	Item	Specification and Quantity
Groundwater Development	1	Drilling Rig	100 m or Deeper, 4WD Vehicle, DTH Hammer and Mud Drilling
	2	Hammers and Bits	Appropriate Diameter
	3	Temporary Casings	for 60 m
	4	Drilling Tools	
	5	Air Compressor	4WD Vehicle
	6	Truck with Crane	4WD Vehicle
	7	Transportable Workshop	Vehicle type, Necessary Accessaries
	8	Tools for Pumping Test	
	9	GPS	
	10	Electric Logging Device	
	11	Electric Prospecting Device	
	12	Training（Technical support）	For Operation and Maintenance of the Listed Equipment
NRW Reduction	1	Pipe Installation Equipment	
	2	Leak Management Equipment	
	3	Management and Inspection Equipment	
	4	Dredging Equipment	

The contents of the official request submitted from MAIWD in October 2017 are as follows.

Table 1-2: Request for equipment procurement from Malawian side (final version)

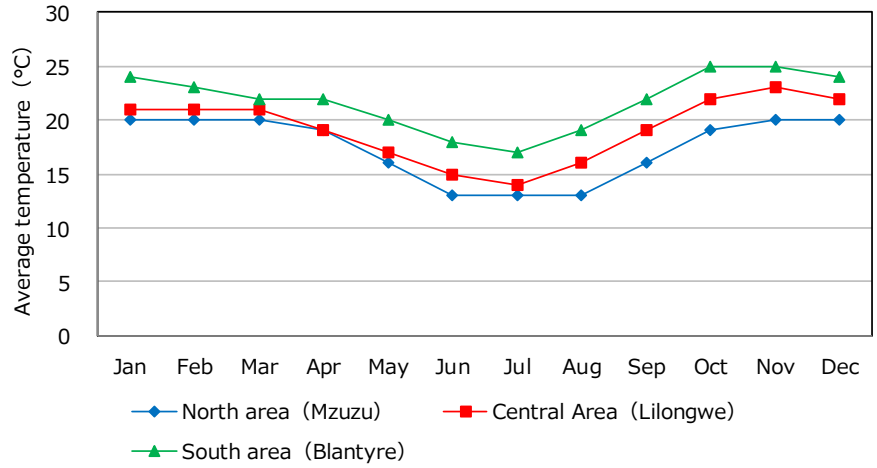
Category		No.	Item	No.	Item
Groundwater Development		1	Drilling Rig	9	Data Logger
		2	Air Compressor	10	Water Gauge
		3	Truck with Crane	11	Depth Gaufe
		4	Drilling Hammer and Bits	12	Borehole Camera
		5	Casings	13	Electric Logging Device
		6	Transportable Workshop	14	Electric Prospecting Device
		7	Tools for Pumping Test	15	Drilling Tools
		8	GPS		
NRW Reduction	Pipe Installation	1	Pipe Drilling Tools	9	Tools
		2	Clamp Saddle	10	Compacter
		3	Pipe Threading Tools	11	Truck with Crane
		4	Butte Welding Machine	12	Engine Pump
		5	Pipe Cutter	13	Lighting Gear
		6	Lifting Tools	14	Small Excavator
		7	Small Generator	15	Pipe Repair Clamp and Dressor Joint
		8	Electric Welding machine		
	Leak Management	1	Leak Detection Tools	5	Pipeline Detector
		2	Portable Ultrasonic Flow Meter	6	Portable GPS
		3	Water Pressure Meter	7	Pressure Reduce Valves
		4	Leak Sound Detection Bar		
	Management and Inspection	1	Accuracy Tester of Water Meter	3	Pickup Truck
		2	Pressure Gauge for Water Faucet	4	Motor Cycle
Soft Component		For Operation and Maintenance of the Listed Equipment			

1-2 Natural Conditions

1-2-1 Natural Conditions

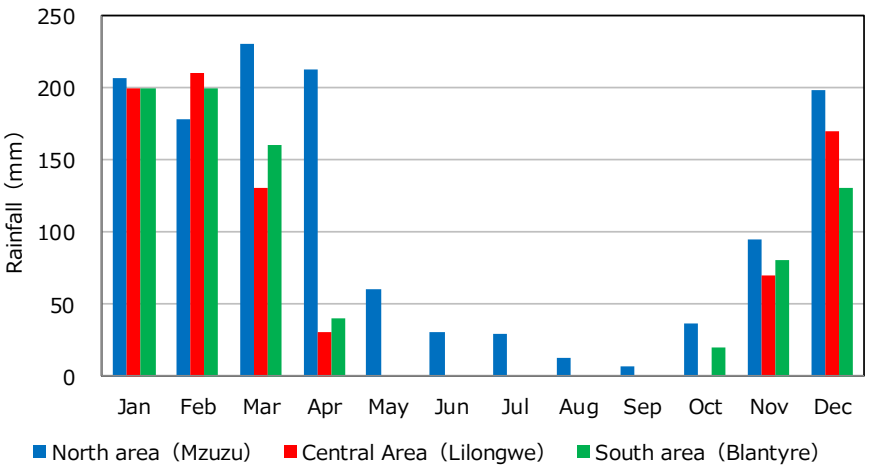
(1) Weather Conditions

Malawi belongs to the tropical savanna climate. The seasons are divided into rainy season (November to March) and dry season (April to October). Annual rainfall of around 1,000 mm is expected through the entire area except steep mountainous areas. The average temperature is 16 to 21 °C from April to September and 23 to 24 °C from October to December. It is around 22 °C during January to March because hours of daylight is shorter when there is higher rainfall.



Source : weatherbase (http://www.weatherbase.com)

Figure 1-1 : Average temperature in Malawi



Source : weatherbase (http://www.weatherbase.com)

Figure 1-2 : Average rainfall in Malawi

(2) Topography

Malawi is situated in the southeastern part of the continent of Africa between latitudes 9°～17° south and longitude 33°～36° east. The country extends from north to south (855 km), and it is bordered by

Mozambique to the southeast, Zambia to the west and Tanzania to the north. It has a geographical area of 118,000 km2, of which one fifth is occupied by Lake Malawi (23,000 km 2). Malawi can be divided into the following four terrain characteristics.

◆ Rift Valley Plain

The rift valley plains extend along the shores of Lake Malawi; and Shire Valley and the shores of Lake Chirwa in the south. It is located below 600 m above sea level, is gently sloping and of very low relief. The fault scarp of the rift valley plummets from the lake surface (474m above sea level) to the water depth of 500m and extends south along both sides of the Shire River Valley.

◆ Rift Valley Escarpment

Rift valley escarpment is a scarp between low rift valley plain and plateau area, and runs through the nation in the north-south directions with the altitude of 500 to 1,100 m. The area is highly dissected and the basement complex is exposed due to erosion.

◆ Plateau Area

Plateaus area occupies the majority of the western region up to the boarder with Zambia, and the southeast part up to the boarder with Mozambique. It is a low-relief plain, which has gently undulating surfaces with an altitude of 1,100 to 1,400 m.

◆ Highland Area

The highland area comprises isolated hills rising abruptly in plateaus; the most prominent hills are Nyika Plateau in the north (2,600m), Mt. Viphya (2,058m) and Mt. Dedza (2,198m) in the central part and Mt. Mulanje-Sapitwa (3,000m) in the south.

The geological condition of Malawi is characterized by the Peneplain and Inselberg Hill, formed by structural deformation due to repeated orogenic movements, and long-term weathering under tropical conditions.

(3) Geology

The geology of Malawi comprises the Mozaimbique belt from Precambrian to early Paleozoic; it is mainly covered by metamorphic rocks composed of gnesis and plutonic rocks composed of garanite and gabbro. The distribution range of other rocks is extremely small, and it is found only in a part of the northern and southern regions.

The Mozambique belt undergoes structural deformation due to repeated orogenic movements. The structural lines dominate in the northwest to southeast direction, followed by the north-south and east-west directions. Faulting commenced at Cenozoic era has formed the rift valley, which runs through Malawi and the movement crushed the surrounding area of the rift valley and formed numerous fault fracture zones and fissures.

Early Paleozoic metamorphic rock (P) and Mchinji group including late Paleozoic metamorphic rock (MI) and pluton (Md) is distributed in the Mozambique belt, which much of Malawi is made up of. Early Paleozoic metamorphic rock (P) is distributed in almost the entire region and composed of quartz-feldspar granulite/gnesis (Xgg), hornblende mica genesis (Xh), biotite genesis (Xs) and quartrite (Xq). A part of the

region consists of some minerals such as graphite, garnet and acmite.

The surface soil of the upper basement complex is covered by vulnerable highly weathered zones such as sediments and soft rocks, followed by weakly weathered zones where cracks are likely to develop in the lower part. Weathered zones rarely exist in the region where rocks of residual hills are formed. In addition, even at the plateau area, weathered zones may become thin where dykes are distributed under the surface sediments.

Surface sediments are divided into alluviums, which is distributed in lowlands along the either DAMBO or Bua River system and the Linthipe River system; and weathered soils of the basement complex, which is distributed higher than these lowlands. Weathered soils are mainly brownish laterites or viscous soils consolidated in soft rocks. Meanwhile, the region where the strata of the Mchiji group are distributed, grayish yellow sandy soils containing a large amount of quartz grains are distributed. Alluvium sediments and DAMBO sediments are predominantly fine gray strata particular to the stagnant water area. However, these sediments include sandy and organic soils because the sedimentary facies have changed due to gentle slopes of the river, causing significant movement of the channel.

(4) Hydrogeology

The highland area is covered with surface sediments. Weathered parts of the basement complex consist of gneiss (ranging from sediments to crack development) are mainly distributed, and thus favorable aquifers are stored in these areas. However, the thickness of weathered zones varies from region to region, and in some regions, there are few weathered zones. In particular, the zones are thin in areas where intruding rocks are distributed. At these areas, groundwater storage is rarely expected. On the other hand, except for weathered rock stratum, groundwater storage is expected to exist in fractured zones of the basement complex, distributed along structural lines such as faults. However, in regions where there are no topographical features and are covered with thick surface sentiments, the continuity of the sediments need to be confirmed.

In addition, aquifers can be found in areas with coarse particle size (sandy soil, gravely soil, etc.) in surface sediments (alluvium, DAMBO sediments, weathered residual soil, etc.). Nevertheless, these aquifers are easily affected by the amount of rainfall because groundwater at these aquifers are unconfined. Moreover, groundwater is likely to be limited due to the thin stratum for storage and the high possibility of the lack of continuity.

1-2-1 Groundwater Storage Prospect

(1) Overview

MAIWD conducted the Hydrogeological Survey to explore the possibility for deep groundwater development throughout Malawi by entrusting to consultants from South Africa, UK and Malawi based on the funds of International Development Association (IDA) between 2014 and 2015. National Hydrogeological and Water Quality Mapping Geophysical Survey completed geophysical prospecting at 41 sites [1] (North: 14 sites, Central: 17 sites, South: 9 sites), while Hydrogeological and Water Quality Mapping Consultancy in Shire River Basin Geophysical Survey was completed at 32 sites[2] (Central: 2 sites South; 30 sites). The geological prospecting (vertical electrical soundings with resistivity method) is carried out to confirm deep

[1] Consultancy Services for National Hydrogeological and Water Quality Mapping Final Geophysical Survey Report (March 2015)
[2] Hydrogeological and Water Quality Mapping Consultancy in Shire River Basin Draft Geophysical Survey Report (June 2017)

underground structure from a physical point of view. In addition, exploratory drilling survey is conducted at 40 sites[3] (drilling depth: 62 to 104 m) in National Hydrogeological and Water Quality Mapping Geophysical Survey.

Table 1-3 : Outline of geophysical prospecting and exploratory drilling survey

	Geophysical Prospecting Survey				Exploratory Drilling Survey	
	National Hydrogeological Geophysical Survey		Shire River Basin Geophysical Survey		National Hydrogeological Geophysical Survey	
	Site	Prospect Depth	Site	Prospect Depth	Site	Drrilling Depth
North	14	150 m			14	62～102 m
Central	18	150 m	2	400 m	17	65～104 m
South	9	150 m	30	400m	9	80～100 m
Total	41	150 m	32	400 m	40	62～104 m

(2) Evaluation of Survey Results

1) Resistivity Classification in Malawi

The resistivity curve (ρ-a curve) obtained by the geophysical prospecting is classified into 4 patterns: (a) Bowl-type, (b) Ascending-type, (c) Descending-type, (d) Mountain-type. The hydrogeological subsurface structure is composed of three resistivity layers; the first layer (ρ1 layer), the second layer (ρ2 layer), and the third layer (ρ3 layer) based on the results of the geophysical prospecting.

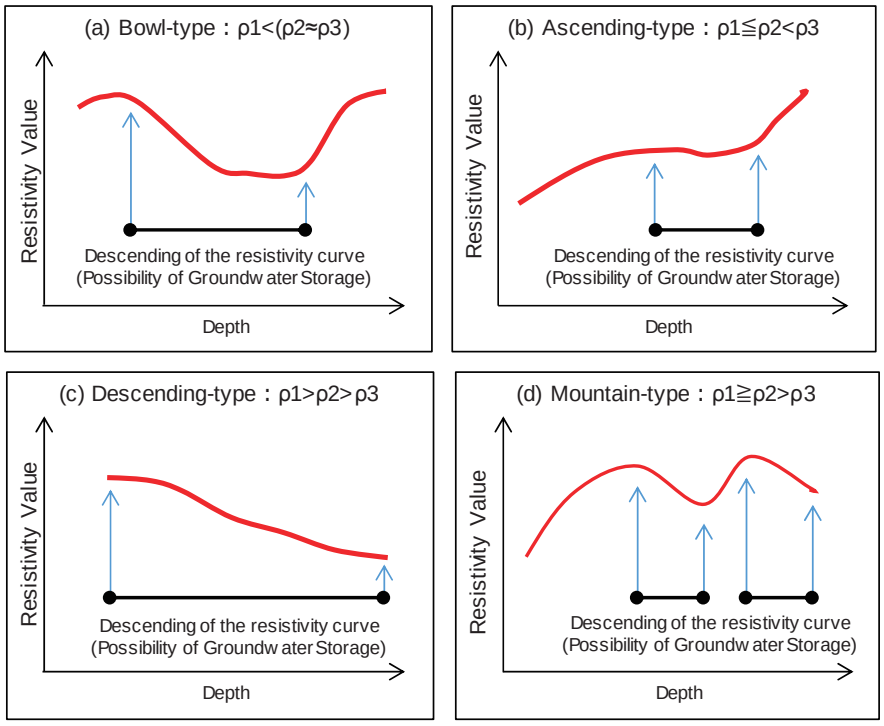


Figure 1-3 : Resistivity curve pattern

Generally, groundwater (water resource) is likely to be present at the point where the resistivity curve is descending.

[3] Consultancy Services for National Hydrogeological and Water Quality Mapping Draft Exploratory Drilling Report (October 2015) and Annex V-Master BH Dataset.xls in Water Resources Investment Strategy Component 1- Water Resources Assessment Annex V-Groundwater (April 2011)

2) Evaluation of Groundwater Storage

(a) Bowl-type

The bowl-type is characterized by the resistivity curve descending from the ground surface (ρ1 ~ ρ2 layer) and rise to ρ2 or ρ3 layer after the stable phase.

North and Central Region

The depth at which descending of the resistivity curve stops, that is, the depth at which water resource is found, is approximately 7 to 30 m (deepest 50 m). The apparent resistivity value (ρ-a curve) of the ascending part (ρ2 or ρ3 layer) of the resistivity curve is 30 to 6,000 Ohm*m. Based on the apparent resistivity value and existing geological map, the part of ascending curve is presumed as hardrock facies such as metamorphic and plutonic rocks.

South Region

The depth at which descending of the resistivity curve stops, that is, the depth at which water resource is found is approximately 7 to 30 m (deepest 50 m). The apparent resistivity value of the ascending part (ρ3 layer) of the resistivity curve is 4 to 130 Ohm*min in areas where Tertiary and Quaternary sedimentary layers are distributed, while other areas have different values of 50 to 20,000 Ohm*m. Overall, most of the apparent resistivity value is 300 to 3,000 Ohm*m. In ρ1 to ρ2 layers, saline groundwater is estimated in the part where the resistivity value continuously shows 50 Ohm*m or less. Based on the apparent resistivity value and the existing geological map, the part of the ascending curve (ρ2 and ρ3 layer) is presumed to have hardrock facies such as metamorphic and plutonic rocks. In the ascending curve on the ρ-a curve from ρ2 to ρ3 layer, where the resistivity value is 300 to 3,000 Ohm*m and random variations (turbulence) are observed, there is a possibility of fissure water at the second aquifer, which is governed by fractured zones of the basement complex and faults.

(b) Ascending-type

In the ascending-type, the resistivity curve rises from the ground surface (ρ1 layer) and it goes through the stable phase (ρ2 layer) before rising to the ρ3 layer.

North and Central Region

The apparent resistivity values of ρ2 and ρ3 layer is approximately 50 to 5,000 Ohm*m. These ρ2 and ρ3 layers are presumed to have hardrock facies such as metamorphic and plutonic rocks, similar to "(a) Bowl-type". In the ascending curve on the ρ-a curve from ρ2 to ρ3 layer, where the resistivity value is 50 to 5,000 Ohm*m and random variations (turbulence) are observed, there is a possibility of fissure water at the second aquifer, which is governed by fractured zones of the basement complex and faults.

South Region

The apparent resistivity value of ρ2 and ρ3 layers is approximately 50 to 20,000 Ohm*m. These ρ2 and ρ3 layers are presumed to have hard rock facies such as metamorphic rocks and plutonic rocks, similar to "(a) Bowl-type". In the resistivity value (50 to 20,000 Ohm*m) of the third layer (ρ3 layer), where random variations (turbulence) of the apparent resistivity value of 1,000 Ohm*m or less are observed, there is a possibility of fissure water at the second aquifer, which is governed by fractured zones of the

basement complex and faults. Saline groundwater is unlikely to be contained in this resistivity section. In addition, the possibility of deep groundwater (deeper than 100 m) is presumed to be low in the areas with the resistivity section.

(c) Descending-type

In the descending-type, the resistivity curve descends continuously, as the depth of prospecting from the ground surface deepens. In other words, the feature of the descending part is to have a high possibility of continuous groundwater storage.

North and Central Region

The apparent resistivity value is extremely low, 8 to 85 Ohm*m. Decrease or disturbance of the apparent resistivity value deeper than 80 m shows the possibility of fractured zones of the basement complex and faults in the area.

South Region

In south region, saline groundwater is expected to contain and in particular, it is presumed to concentrate on ρ2 layer. The apparent resistivity value of the saline aquifer is extremely low as 5 to 30 Ohm*m as a whole. The apparent resistance curve descends continuously throughout ρ1, ρ2 and ρ3 layers, and the resistance value is less than 30 Ohm*m. Furthermore, some sites have the low resistivity layer (30 Ohm*m or less), which continues from the surface soil to a depth of 400 m. In these sites, the resistivity value is likely to descend due to the influence by groundwater at upper layers (ρ1 or ρ2 layer), which contains salinity. Alternatively, there is a possibility that the low resistivity value is shown owing to fissure water at the third aquifer, which is governed by fractured zones of the basement complex and faults.

(d) Mountain-type

In the Mountain-type, the apparent resistivity value rises as the depth from the ground surface deepens and it stabilizes at the middle depth before it descends again.

North and Central Region

The apparent resistivity value is an intermediate value of 100 to 1,000 Ohm*m. The apparent resistivity value of the part of the descending curve on the third layer (ρ3 layer) is as wide as 50 to 5,000 Ohm*m. When random variations (turbulence) of the resistivity value are observed in the deep section (approximately 60 m or deeper), there is a possibility of fissure water, which is governed by fractured zones of the basement complex and faults.

South Region

The apparent resistivity of the descending part (ρ3 layer) on the ρ-a curve is extremely low as 10 to 20 Ohm*m. When random variations (turbulence) of the resistivity value are observed in the descending part of the third layer (ρ3 layer), there is a possibility of fissure water, which is governed by fractured zones of the basement complex and faults.

3) Thickness of Strata by Geography

Based on the results of the geophysical prospecting and the exploratory drilling survey, the average layer thickness based on rock facies of underground stratum are assumed for each presumed drilling depth (100 m and 200 m).

Table 1-4 : Layer thickness assumption（for Depth of 100m）

Unit : m

	First Layer	Second Layer	Third Layer		Total Depth
	Weak Stratum	Soft Rock	Medium-hard Rock	Hard Rock	
Plain (lowland)	9.1	65.0	25.9	0.0	100.0
Valley Plain	11.6	67.0	21.4	0.0	100.0
Escarpment	8.0	45.5	46.5	0.0	100.0
Plateau	7.3	55.0	37.7	0.0	100.0
Mountanious	8.5	58.0	33.5	0.0	100.0

Table 1-5 : Layer thickness assumption（for Depth of 200m）

Unit : m

	First Layer	Second Layer	Third Layer		Total Depth
	Weak Stratum	Soft Rock	Medium-hard Rock	Hard Rock	
Plain (lowland)	9.1	65.0	75.9	50.0	200.0
Valley Plain	11.6	67.0	46.4	75.0	200.0
Escarpment	8.0	45.5	96.5	50.0	200.0
Plateau	7.3	55.0	87.7	50.0	200.0
Mountanious	8.5	58.0	67.0	66.5	200.0

4) Evaluation on Hydrogeological Structure

North and Central Region

As the results of the geophysical prospecting (ρ-a curve), the following items were examined comprehensively; screen position of borehole loggings (groundwater-intake part); compositions of the basement complex, which accounts for most of the underground geology of Malawi (metamorphic rocks and plutonic hardrock layers); and the distribution of great rift zone, located on the south extension line of rift valley. The following hydrogeological structure is estimated.

- It can be categorized into three (ρ1, ρ2 and ρ3 layer) resistivity layers (possibility of groundwater storage).
- The ρ1 layer corresponds to the weak stratum (weathered layer and recent sedimentary layer) of the surface soil. In addition, the ρ1 layer reflects the thick sedimentary layers originating from Lake Malawi, and thus the form of groundwater storage in this geological stratum is presumed as stratum water (unconfined or weakly confined groundwater).
- Although the ρ2 layer is a bedrock layer, it is characterized by weathered zones, fractured zones and faults. Thus, the presence of fissure water is estimated.
- The ρ3 layer is the basement complex; fractured zones and faults in rock layers can be found in some areas. Thus, the presence of fissure water is estimated.
- It is estimated that fissure water is present in ρ2 layer, as the intake layer of existing boreholes is less

than 90 m.

- The yields of existing boreholes for ρ1 and ρ2 layers are mostly 3ℓ/s or less. In addition, yields of 10 ℓ/s were confirmed at 6 sites where stratum water exists, while yields of 5 ℓ/s were identified at 6 sites where highly weathered fissure water exists.
- The groundwater (the first aquifer) in ρ1 and ρ2 layers is presumed to be weakly confined or unconfined groundwater, and it is considered as poor aquifer even judging from results of the pumping test.

South Region

The geophysical prospecting at 32 sites at a depth of 400 m has been conducted in the south region. However, there is no existing data of boreholes such as borehole loggings, and thus comparison verification with the result of the geophysical prospecting (the resistivity value) cannot be conducted. Nevertheless, the hydrogeological structure is estimated after examining the following items comprehensively; compositions of the basement complex, which accounts for most of the underground geology of Malawi (metamorphic rocks and plutonic hardrock layers) and the distribution of the great rift zone, located on the south extension line of the Rift Valley. The following hydrogeological structure is estimated.

- It can be categorized into three (ρ1, ρ2 and ρ3 layer) resistivity layers.
- The ρ1 layer corresponds to the soft rock layer of the surface soil (weathered zones and recent sedimentary layer).
- A thick sedimentary layer, originating from lowland along Lake Malawi and Shire River, is distributed and it corresponds to the ρ1 layer in the resistivity section. Stratum water is estimated to be stored (weakly confined or unconfined groundwater) in the ρ1 layer of this section.
- Although the ρ2 layer is a bedrock layer, it is characterized by weathered zones, fractured zones and faults. Thus, the presence of fissure water is estimated.
- The ρ3 layer is the basement complex and fractured zones and faults in rock layers can be found in some areas. Thus, the presence of fissure water is estimated.
- In the ρ-a curve of "(c) Descending-type", some sites have the extremely low apparent resistivity, that is 5 to 30 Ohm*m at the depth of 150 to 400m. This is because the resistivity value at ρ3 layer (30 Ohm*m or less) is affected by saline groundwater at the upper layer (ρ1 or ρ2 layer).
- In the low resistivity layer at 150m or deeper, the presence of fissure water is estimated at the basement complex (ρ3 layer), which is governed by fractured zones of the basement complex and faults.

Shallow Aquifer

The shallow aquifer is evaluated as follows.

- In 41 sites where the geophysical prospecting was conducted, borehole drillings are carried out at 41 sites and pumping tests are carried out at 40 sites. Most of these existing boreholes yield 3 ℓ/s or less. However, some boreholes yield 10 ℓ/s (stratum water: 6 sites) and 5 ℓ/s (highly weathered fissure

water: 6 sites).

- Sites with high yields (10 ℓ/s) are observed at Rift Valley Plain, which is along the eastern-side rift valley along the mountain range penetrating through the center of Malawi and Rift Valley Escarpment, which is a scarp between low rift valley plain and plateau. Thus, the type of groundwater at these sites is estimated as stratum water (weakly confined or unconfined groundwater).
- Sites with relatively high yields (5 ℓ/s) are observed at Peneplain, widely distributed in the plateau area on the west side of the Central Mountain Range and base of the mountains (mainly at the junction with mountains and plateau). Therefore, the type of groundwater at these sites is estimated as confined fissure water.
- The initial water level of the groundwater at existing boreholes at 41 sites is 4 m at the shallowest and 25 m at the deepest. Among 41 sites, the initial water level of less than 10 m is found at 21 sites, 11 to 15 m is at 10 sites, 16 to 25 m is at 7 sites, and it cannot be measured at 3 sites. These results show the initial water level of the first aquifer is relatively shallow.
- As the results of the pumping test of 40 existing boreholes, the initial water level is shallow at the sites where boreholes yield 10 ℓ/s. The water level drop during the pumping test at these sites is less than 10 m (the drawdown of one site is 22 m) and this indicates a very favorable aquifer condition. Although the initial water level at the site of 5 ℓ/s is relatively shallow at the depth of 6 to 21 m, the water level drop during the pumping test is as wide as 6 to 40 m. This suggests fissure water is taken mostly, which is governed by hydrogeological structure.

(3) Possibility of Deep Aquifer Development

There are no clues to evaluate quantitatively the underground geological structure because neither MAIWD nor private drilling companies have drilling records deeper than 100 m, and data such as geological samples and borehole loggings are not sufficient. Thus, it is not possible to verify the hydrogeological structure at present, even if there is a result of the geophysical prospecting exceeding 100 m. Consequently, the possibility of development of deep aquifer is examined using the result of the geophysical prospecting.

North and Central Region

In north and central region, the possibility of fissure water is estimated in the deep part of the second layer (ρ2 layer) and the third layer (ρ3 layer) at 8 sites (A rating: 4 sites, B rating: 4 sites). At these sites, groundwater storage at depth of 100 ~ 200 m is expected.

South Region

According to the results of the geophysical prospecting, most of the groundwater sources are in the lowland where the thick sedimentary layer of Lake Malawi and Shire River is distributed and is occupied by stratum water (continuously from ρ1 to ρ2 layer). In places other than lowland, the presence of fissure water (the second aquifer) is estimated in the second layer (ρ2 layer) and the third layer (ρ3 layer). In south region, the possibility of existence of the second aquifer is estimated at 10 sites (A rating: 6 sites, B rating: 4 sites). The breakdown is as follows. A rating (6 sites) has stratum/fissure water at 1 site, stratum water at 3 sites and fissure water at 2 sites. B rating (4 sites) has stratum water at 1 site,

stratum/fissure water at 1 site and fissure water at 2 sites. In south region, shallow groundwater with salinity may exist. Therefore, MAIWD shall consider using the watersealing method on the shallow layer, which contains salinity, in order for the deep aquifer to be developed.

Table 1-6 : Evaluation on deep aquifer development

No.	Region	District	Site	Geophysical Prospecting Survey Results			Evaluation
				Predicted Water Strike Depth (m)	Resistivity (Ohm*m)	Groundwater Aquifer	
1	North	Karonga	Kaporo	40~150	85	Stratum/Fissure	A
2			Mulale	50~150	32~70	Stratum/Fissure	A
3		Chitipa	Nthalire	40~70	110~1,000	Fissure	B
4		Rumphi	Mzokoto	40~150	80～140	Fissure	B
5	Central	Nkhotakota	Kamphambale	80~150≦	30～85	Fissure	A
6		Kasungu	Kapelua	40~120	30~3,000	Fissure	B
7		Kasungu	Lisandwa	80~150≦	1,400	Fissure	A
8		Lilongwe	Nanthenje	50~150≦	230～3,000	Fissure	B
9	South	Mangochi	Malindi	20~150≦	4~100	Stratum/Fracture	A
10			Chantulo*	60~150≦	5～7	Stratum	A
11		Zomba	Magomero	50~150≦	50~860	Fissure	A
12		Machinga	Nselema-Button	50~150≦	120～920	Fissure	B
13		Chikwawa	Ngabu	90~200	3～20	Stratum/Fracture	B
14			Chambuluka	60~180	35～65	Fissure	A
15			Mitondo*	80~250	10～30	Stratum	A
16			Namalidi	100~200	4～20	Stratum	B
17		Balaka	Namalomba*	100~300	5～10	Stratum	A
18			Buke	40~230	400～2,000	Fissure	B

* Saline groundwater may exist in shallow aquifers

(4) Possibility of Shallow Aquifer Development

Based on the results of qualitative analysis of existing boreholes as well as the resistivity curve (ρ-a curve) of the geophysical prospecting, the possibility of developing the shallow aquifers (the first aquifer) is examined. As a result, it is judged that shallow aquifers in some areas can secure further yields, that is, enhance the yields of one borehole. In areas where existing boreholes with 4 inch-diameter have the yield of 5 ℓ/s or more, greater yields than present are expected by enlarging boreholes with 6 to 8 inch-diameter and installing a large-scale submersible pump. In the same groundwater basin, it is better to secure borehole yields by a fewer number of boreholes with large-diameter than larger number of boreholes with small-diameter. The reason is because a fewer number of boreholes enable to prevent a decrease in yields owing to total interference between boreholes and it contributes to maintain sustainable yields as well as preserve groundwater.

North and Central Region

The results of the geophysical prospecting and pumping tests identify the areas where an increased yield is expected at the first aquifer. North region has 5 sites (A rating: 3 sites, B rating: 2 sites), central region has 2 sites (A rating: 2 sites). Of these areas, Kaporo and Nyungwe (Karonga District in north region), are consistent with the location of the market center where MAIWD gives priority to development, and both have A ratings. Therefore, increased yields of existing boreholes is expected in these areas by enlarging borehole diameter and installing a large-scale submersible pump.

South Region

Areas where further yield increases at the first aquifer are evaluated as 4 sites (A rating: 3 sites, B rating: 1 site). Among them, Malindi (Mangochi District) is consistent with the location of the market center, and has an A rating. Therefore, increased yields of existing boreholes are expected in the area by enlarging borehole diameters and installing large-scale submersible pumps.

Table 1-7 : Evaluation on shallow aquifer development

No.	Region	District	Site	Borehole Capacity			Evaluation	Market Center Location
				Depth (m)	Yields (ℓ/s)	Drawdown* (m)		
1	North	Karonga	Kaporo	100	10.0	8.0	A	○
2			Mulale	64	10.0	10.0	A	
3			Nyungwe	100	10.0	10.0	A	○
4		Chitipa	Nthalire	102	5.0	36.0	B	
5		Rumphi	Chakoma	80	5.0	40.0	B	
6	Central	Nkhotakota	Liwaladzi	70	10.0	0.7	A	
7			Kamphambale	101	10.0	22.0	A	
8	South	Mangochi	Chantulo	80	5.0	6.0	A	
9			Katema	95	2.5	0.8	B	
10			Malindi	80	10.0	12.5	A	○
11		Zomba	Magomero	100	5.0	18.0	A	

* Drawdown＝Dynamic Water Level (DWL)－Static Water Level (SWL)

1-3 Environmental and Social Considerations

(1) Environmental and Social Considerations

The Project has a minimal or virtually no impact on the environment and society and it is classified as “Category C” according to JICA Guidelines for Environmental and Social Considerations. Procured equipment for the Project shall be either stored at LWB’s warehouses or installed within LWB’s facilities. The implemenation of the Project requires an expansion of a warehouse at LWB headquarters and a foundation work to install a back-up generator. These construction works will be done at sites of LWB Offices, which is not located within designated conservation areas. Therefore, the Project has a minimal impact on local communities and natural environment.

(2) Land Aquisition/Resettlement

The Project does not require either land acquisition or resettlement.

(3) Others

No other special instructions regarding Environmental and Social Considerations are required.

Chapter 2 Contents of the Project

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

2-1-1 Project Objective

The Government of Malawi (GoM) placed a high priority on water resource development in line with the MGDS II to improve the water supply situation in urban and rural areas. In Lilongwe City, LWB is working on reducing the Non-Revenue Water (hereinafter referred to as "NRW") rate to 28% by 2020. Nevertheless, the results of the effort are limited. Meanwhile, in rural areas, MAIWD aims to improve an access to safe drinking water through developing groundwater in confined aquifers. However, equipment capable of drilling deeper than 100 meters does not exist in Malawi.

The Project for Improvement of Groundwater Development and NRW Reduction in Malawi (hereinafter referred to as "the Project") aims to contribute to the stable water supply in Lilongwe and rural areas. The Project will enhance the water-use efficiency in the city and strengthen the structure with the hope of increased drinking water in rural areas through the maintenance of equipment for groundwater development and NRW reduction.

2-1-2 Project Outline

The Project aims to procure drilling equipment of deep groundwater development and technical support (soft component) for MAIWD, and equipment for pipe installation; leak management; management and inspection for LWB after examining the relevance. Improvement of the water supply situation in urban and rural areas of Malawi shall be expected through capacity enhancement of deep drilling for MAIWD and management of NRW for LWB after the implementation of the Project.

2-2 Outline Design of the Japanese Assistance

2-2-1 Design Policy

(1) Basic Policy

The Project examines the relevance of each piece of equipment for groundwater development and NRW reduction. Regarding the equipment judged to be relevant, appropriate scales and specifications shall be set as the equipment procurement project in Malawi, in consideration of cost saving.

(2) Policy on Natural Conditions

There are many unpaved roads in Malawi, apart from the main road. All-wheel-drive-vehicle or four-wheel-drive-vehicle shall be fundamentally procured for vehicles and rigs due to the consideration of muddy unpaved roads after the rain. However, two-wheel-drive-vehicle shall be procured for a transporter truck for excavator because low floor type vehicle is safer.

(3) Policy on Socio-Economic Conditions

There are no special considerations required for socio-economic situations.

(4) Policy on Procurement Conditions

In selecting equipment, it is required to identify the supply system of spare parts and select the model that is easier to maintain as much as possible. The equipment shall basically be procured from either Malawi or Japan as the Project is implemented under the Grant Aid Project. In addition, it will also be procured through "the Project for Strengthning the Capacity of NRW Reduction for Lilongwe water Board (hereinafter reffered to as the "JICA Technical Cooperation Project of NRW") implemented by JICA in the future. Thus, its specification and supplier need to be examined considering the affinity with the equipment procured by the JICA Technical Cooperation Project of NRW.

(5) Policy on Operation andur Maintenance

The procured equipment for the Project needs to be operated and maintained properly and continuously in Malawi, and thus specifications shall be as simple as possible.

(6) Policy on Grade Setting for Equipment

The procured equipment for the Project needs to have sufficient durability because it will be operated outdoors in the long term.

(7) Policy on Procurement Method and Schedule

It is assumed that the equipment for the Project will be procured through general competitive bidding for Japanese procurement agancies according to the Policy for Grant Aid Project. The schedule shall be formulated in consiedration of the period required for manufacturing and transporting of the equipment, various procedures, installation, trial operation, initial guidance, and inspection and acceptance.

2-2-2 Basic Plan（Equipment Plan）

2-2-2-1 Relevance of Equipment Procurement

1) Groundwater development

Malawi Rural Water Supply Investment Plan was established in April 2015 in order to improve the access rate of rural water supply to 90% by 2020, based on Malawi Vision 2020 and Water Sector Investment Plan 2007 and 2012. The procured equipment for groundwater development shall be equipment to promote water resource development and rehabilitation of boreholes such as rigs for deep and shallow aquifers; and service rigs in order to achieve the high level of rural water supply. The relevance, effectiveness and sustainability of the procurement for the Project were examined, based on the following five criteria agreed with MAIWD and LWB at the time of the Minutes of Discussions.

◆Policy, Strategy and Plan

As requirements to procure rigs for deep aquifers, MAIWD needs to clearly have a high priority on groundwater development at the depth of 100 m or deeper under their policies and strategies. In addition, they need to have the groundwater development plan that identifies the specific target areas and numbers of projects based on their policies and strategies. These requirements are examined through the Survey; it is confirmed that specific descriptions regarding the high priority of groundwater development of 100 m or deeper were not yet incorporated into overall plans. Accordingly, development plans were not

described in enough detail to include target areas and depth of deep groundwater development. Although MAIWD recognized the necessity of deep groundwater development, they are not able to drill deeper than 100 m owing to a lack of rigs capable of dealing with deep aquifers. Thus, MAIWD could not incorporate deep groundwater development into either overall plans or development plans at present. On the other hand, the surrounding countries such as Zambia, Mozambique and Tanzania, develop groundwater at a depth of 100 m or deeper; MAIWD is able to procure rigs for deep aquifers from the neighboring countries for the purpose of planning or developing deep groundwater. Thus, it is presumed that deep groundwater development has not been promoted in Malawi due not only to the lack of equipment but also to the demand for deep groundwater development and cost for construction.

Meanwhile, MAIWD plans to implement the Level 2 water supply facilities (reticulated groundwater source system) at 74 market centers, selected based on the four criteria (the situation of water supply system, groundwater source availability, aquifer distribution and water quality, and the demand for reticulated groundwater source system) in Malawi Rural Water Supply Investment Plan. Out of 74 market centers, 32 market centers were selected to be developed first, due to the size of the population and current water supply condition. During phase I (2014~2020), implementation of 61 and 54 boreholes are proposed by 2017 and 2020 respectively. African Development Bank (hereinafter referred to as “AfDB”) is working on Water Supply and Sanitation Project to develop seven market centers. This project is operated at Nathenje, Kaisya, Nsalu, Nkando, Malosa, Ntaja and Nsanama and co-financed by Australian Agency for International Development (current Department of Foreign Affairs and Trade: DFAT) under National Water Development Program. These targeted locations are different from the 32 market centers described above.

Malawi Rural Water Supply Investment Plan refers to the rehabilitation of a total of 5,593 existing boreholes, though it does not describe specific target boreholes, years and priorities. The plan is considered as indefinite because the figure was not estimated based on the actual conditions of boreholes. MAIWD examined the number of borehole required rehabilitation through the assumption that approximately 75 % (5,593 boreholes) of the total number of inactive boreholes (7,462 boreholes) reported from each District is repairable. The priority of rehabilitated locations is only mentioned as 21 Districts, where the rate of inactive boreholes exceeds 10%. Under the policy, the maintenance and rehabilitation of boreholes are principally operated at the community level; MAIWD is assigned for a large-scale rehabilitation. However, their services are for a fee and thus, NGOs often take charge of large-scale rehabilitation works because of their lower-cost services and close relations with communities.

◆ Aquifer (Capacity of Development)

Groundwater storage availability including the target depth are examined through the Project by verifying the presence of aquifers based on the existing hydrogeological data as the Project does not include exploratory drilling or geophysical prospecting. The Hydrogeological Survey (geophysical prospecting) conducted between 2014 and 2015 confirmed the possibility of the existence of aquifers at a depth of 100 to 200 m in some areas. However, it is only an estimation based on analysis results of the geophysical prospecting and it could not be verified with the data on drilling and pumping test at a depth

of 100 m or deeper in Malawi.

On the other hand, the Hydrogeological Survey has carried out the exploratory drillings and pumping tests up to a depth of 100m and it found that yields of 5.0 to 10.0 ℓ/s or more can be secured at 12 sites in Malawi and the water-level falls within 22 m or less. The results indicate that the capacity of groundwater storage at shallow aquifers in these areas is high. Enhancing the yields of one borehole can lead to the reduction of the number of boreholes, and still enable attainment of the necessary amount of water. Reduction of the number of boreholes makes operation and maintenance easier and contributes to suppression of operation cost (water fees of beneficiary). It is required to finish a borehole with a larger diameter (6 to 8 inches for inner diameter) rather than normal diameter (4 inches), and install a submersible pump with a large outside-diameter with higher capacity of pumping in order to reduce the number of boreholes. However, Malawi does not have large diameter bits nor are the existing rigs capable of large-diameter bits at present.

◆ Operation and Maintenance Structure of Equipment Management

Technical skills, financial capability and supply system of spare parts are examined, assuming the equipment is procured, since there are no records in operation and maintenance of rigs that are capable of drilling more than 100 m in Malawi.

MAIWD does not have experience drilling more than 100 m. However, they are evaluated to have a capacity of drilling deep aquifers through acquiring the knowledge of deep drilling because the borehole drilling has been operated directly by MAIWD, which accounts for 34 to 108 boreholes per year in the past few years. Furthermore, it can be evaluated that there is no budgeting problem, considering that a fixed amount of funds are secured every year, even though MAIWD's budget for groundwater development is completely dependent on the Borehole Construction and Groundwater Management Fund (hereinafter referred to as "the Borehole Fund"). The source of the Borehole Fund is the construction fee from the customers, who request the borehole construction. MAIWD pays 5 % of the fee to the Ministry of Finance and properly reduces the remaining 95% in order to allot the fee for the construction of another borehole, repairs of equipment and purchase of spare parts as well as the construction for boreholes requested by the customers. It is judged that MAIWD does not have any financial issues as they secure a fixed amount of Borehole Fund every year and raise the Fund for operation and maintenance of the equipment.

In addition, MAIWD is judged to have no issues for the supply chain although specified spare parts of drilling equipment is not available in Malawi. Indeed, they have experienced purchasing spare parts from Japan and South Africa through the Borehole Fund.

◆ Operation and Maintenance Structure of Facility Management

Generally, additional equipment, such as an electric pump, is required to install with boreholes deeper than 100 m because the capacity of deeper boreholes exceed that of hand pumps owing to the yield and pump head. The status of operation and maintenance is examined through the Project to confirm the following procurement requirement for sustainable operation and maintenance of boreholes: well establishment of technical skills; financial capacity; supply chain of spare parts (pumps and boreholes);

and organization, institutions and policies for sustainable.

Considering the population for water supply; the cost for operation and maintenance; and technical difficulties, deep boreholes shall be implemented as Level 2 water supply facilities (submersible pump) at market center, though it is not referred to in the policy. In that case, under the jurisdiction of Urban Water Divisions at District Water Development Offices, Regional Water Boards (North, Central and South) are responsible for maintenance. Furthermore, they are also in charge of maintenance of shallow groundwater development at market centers under the jurisdiction of Urban Water Divisions at District Water Development Offices. They have sufficient experience of maintenance as they have maintained Level 2 facilities for shallow groundwater at several market centers on an independent accounting system.

In addition, 42 of the water supply facilities operated in the community are Level 2 facilities with shallow groundwater. These are operated by Water Users Association (hereinafter referred to as "WUA") under the jurisdiction of Piped Water Divisions at District Water Development Offices. However, compared with hand pump facilities, water supply facilities with an electric pump for deeper groundwater is more difficult to operate and repair. It also requires additional management and repair for the equipment such as reservoirs, distribution pipes and public faucet as well as sustainable electric power. Thus, concern remains regarding the operation and maintenance at community level due to the lack of experience in operating Level 2 facilities.

Level 1 water supply facilities (borehole with hand pump) are operated and maintained by Village Health Water Committee (hereinafter referred to as "VHWC"), and Water Point Committee (hereinafter referred to as "WPC"). However, when a community cannot respond to a break down, a private repair agent for water facilities, called Area Mechanic, provides a repair service for a fee. Under this system, CBM coordinators and Water Monitoring Assistant provide technical guidance on maintenance under the supervision of Department of Water Supply at MAIWD. Both MAIWD and NGOs are responsible for a large-scale rehabilitation; however, as mentioned above, NGOs often take charge of the rehabilitation work because of their close relations with communities.

◆ Capability of Drilling (Including Private Company)

Since the urgent need shall be recognized for the Grant Aid Project as a prerequisite, the drilling capability in Malawi including private companies is examined.

It is evaluated that MAIWD is currently capable of drilling to a depth of 60 to 80 m at most, due to the aged deterioration of equipment. Although there are approximately 20 private drilling companies in Malawi, none of them have a drilling capacity deeper than 100 m. In other words, neither MAIWD nor private drilling companies in Malawi have a drilling capacity deeper than 100 m in Malawi. Furthermore, the maximum diameter of drill bits, which MAIWD and private drilling companies own, is 4 inches and there are no bits with a diameter of more than 4 inches in Malawi.

As mentioned above, there is no significant difference in drilling capacity between MAIWD and private companies and thus, certain division of work, according to the borehole specifications such as depth and diameter, were not found.

With regard to a method of ordering borehole drilling in Malawi, it is often the case that MAIWD and

private drilling companies participate in general competitive bidding. When placing an order with MAIWD, it is necessary to pre-pay the expense to the Borehole Fund. On the other hand, in the case of placing an ordering with private drilling companies, contingent fee system (no compensation will be paid if drilling does not yield any water) is adopted as Malawi's commercial practice. Thus, it is often decided whether to make general competitive bidding or placing an order to MAIWD, based on the purpose of borehole drilling, difficulty (success rate), budget source and budget amount. Hence, MAIWD does not have superiority in general competitive bidding for shallow groundwater development.

The results of evaluation based on the above consideration are as follows.

Table 2-1 : Result of evaluation for assumed procurement equipment

	Drilling Rig (Deep Aquifers, Large Diameter)	Drilling Rig (Shallow Aquifers, Large Diameter)	Service Rig (Maintenance Vehicle)
① Policy, Strategy and Plan	"Negative" Intend to develop deep aquifers, however concrete development plans exist for only shallow aquifers	"Middle" Development plan for shallow aquifers exists for market centers, however a high feasibility of drilling large-diameter boreholes found at only three sites	"Middle" Borehole rehabilitation in rural areas done by communities, while market centers done by Water Boards (MAIWD is for large-scale rehabilitation)
② Aquifer (Capacity of Development)	"Middle" Possibility of deep aquifers at some areas, however results cannot be verified without drilling records	"Positive" High groundwater storage found at shallow aquifers	
③ O&M Structure of Equipment Management	"Positive" MAIWD acquired equipment operation and experienced purchasing spare parts from foreign countries.	"Positive" -ditto-	"Positive" -ditto-
④ O&M Structure of Facility Management	"Middle" Communities have less experience of O&M for deep boreholes, while Water Boards has sufficient experiences for market centers.	"Positive" MAIWD has sufficient experiences in operation and maintenance of shallow boreholes.	"Middle" Borehole rehabilitation in rural areas done by communities, while market centers done by Water Boards (MAIWD is for support)
⑤ Capability of Drilling (including Private company)	"Positive" Neither MAIWD nor private drilling companies have drilling capacity deeper than 100m	"Positive" Neither MAIWD nor private drilling companies have drilling capacity of 8inch-diameter.	"Middle" Existing heavy machinary can fix and rehabilitate boreholes.
Evaluation	Low priority	Middle priority	Low priority

Remark: "Positive", "Middle" and "Negative" in the table indicate the evaluation results of each criteria.

Drilling Rigs for Deep Aquifers

MAIWD plans to construct 1 to 7 boreholes of 40 to 55 m at each of the 32 market centers in Malawi Rural Water Supply Investment Plan; however, specific descriptions of deep groundwater development were not incorporated into the plan yet, and it is still under progress at present. In addition, as mentioned above, neither other overall plans nor development plans make mention of deep groundwater development.

Furthermore, the result of geophysical prospecting confirmed the possibility of aquifers at a depth of 100 – 200 m in some areas. Nevertheless, it could not be verified because there are no records of drilling deep aquifers (underground geological data deeper than 100 m).

Thus, it is considered as premature to procure the rig with a large-diameter for deep aquifers because a plan respecting the use of rigs is still in preparation and concern remains about whether it will be fully utilized if it

is procured.

Drilling Rigs for Shallow Aquifers

As mentioned above, MAIWD plans to construct 1 to 7 boreholes of 40 to 55 m at each of the 32 market centers in Malawi Rural Water Supply Investment Plan. As for shallow groundwater development, the overall plan exists. Furthermore, the geophysical prospecting conducted by MAIWD, carried out the pumping test at 41 sites nationwide and three of these sites corresponded with the location of market centers. Based on evaluation of pumping test results, these three sites are identified to have a capacity of groundwater storage at shallow aquifers, which means they can endure water-level drops while using submersible pumps.

Procurement of the rig for shallow aquifers with large diameter may contribute to the reduction of operation cost (electricity fee) as well as improvement of operation and maintenance because it enables to enlarge boreholes and use a large-scale submersible pump at market centers, where the construction of several boreholes are planned.

In addition, three out of four rigs owned by MAIWD have exceeded their service life. The service life for the equipment is generally five years and thus the procurement of drilling equipment is important in terms of the renewal of equipment.

However, currently three sites out of the 32 market centers have a possibility of developing shallow boreholes with large diameter and it is hard to secure the specific aims in other areas. Thus, the cost effectiveness of equipment procurement is judged as insignificant; hence the rig for shallow aquifers is excluded from the procurement.

Service Rigs

Under the operation and maintenance system for water supply facilities, local communities are responsible for rehabilitation of boreholes at rural areas, while Regional Water Board is in charge at market centers. The role of MAIWD for operation and maintenance is only a large-scale rehabilitation of boreholes. Thus, it is considered that service rigs are not guaranteed to be used properly and continuously. Furthermore, both MAIWD and private companies are able to utilize existing rigs for borehole rehabilitation.

Conclusion

The relevance of procurement is examined for equipment of groundwater development (rigs for deep/shallow aquifers and service rigs). As a result, further investigation is required to determine the relevance of procurement; however, the present situation is judged not to meet the criteria agreed at the start of the Survey. Thus, the equipment of groundwater development is excluded from the scope of the Project.

However, the possibility of developing new water resource in Malawi will expand when development plans for groundwater, particularly for deep aquifers or shallow aquifers with large diameter, are put into concrete shape.

2) NRW Reduction

LWB, which has jurisdiction over the water supply in Lilongwe City, placed a high priority on making maximum use of the limited water resource of Lilongwe River, located downstream of Kamuzu Dam, in line with MGDS II. LWB established the Strategic Plan to make the most use of water resources and clarify four (4) strategic issues as follows:

- Unreliable Water Supply Service
- Weak Customer Relations
- Limited Financial Capacity for Infrastructure Development
- Inadequate Institutional Capacity

"Simplified Water Supply Plan in Lilongwe City" was established to deal with above strategic issues by the consultation with LWB and Survey Team during the Survey. As a result, the measures for improving the water supply situation organized as (1) Water Resource Development, (2) Expansion and Rehabilitation of Pipes (3) Strengthening Financial Capacity and (4) NRW Reduction.

Table 2-2 : Relevance between strategic issues and measures for improving the water supply situation

Measures for Improving the Water Supply Situation (Draft)	Four Strategic Issues			
	Unreliable Water Supply Service	Weak Customer Relations	Limited Financial Capacity for Infrastructure Dev.	Inadequate Institutional Capacity
①Water Resource Development	○	○	○	
②Expansion and Rehabilitation of Pipes	○	○	○	
③Strengthening Financial Capacity	○	○	○	
④NRW Reduction	○	○	○	○

The progress of measures and detailed activities to improve water supply situation in Lilongwe City are as follows.

Table 2-3 : The progress of measures and detailed activities

Policy (Draft)	Concrete Initiatives	Implementing Entity
①Water Resource Development	Renovation and Raising of Kamuzu Dam	EIB
	New Construction of Water Treatment Plant	World Vank
②Expansion and Rehabilitation of Pipes	Expansion and Rehabilitation of Main Water Supply I	EIB, World Bank
③Strengthening Financial Capacity	Stable Water Fee Collection (Installation of Prepaid Meter)	LWB
④NRW Reduction	Separation by DMA Establishment	LWB, Vitens
	Training of Caretakers	Vitens
	Improvement of Working Quality	LWB
	Procurement of Countermeasure Equipment	None

① Water Resource Development

Expansion of water resource amount leads to an increase in water amount supplied to Lilongwe and thus, it can greatly contribute to the improvement of water utilities and reduction of NRW. LWB sets the "Renovation and Raising of Kamuzu Dam I" and "Maintenance of Water Treatment Plant (Treatment Works III)" as a medium-term target in the "Infrastructure Investment Plan". The Project for Kamuzu Dam aims to increase water resource capacity by raising the retaining wall (H=5.0m approx.) of

Kamuzu I (4.5 to 19.6 Mm^3) and rehabilitation of Kamuzu II (19.8 Mm^3), planned by European Investment Bank (hereinafter referred to as "EIB"). LWB is making progress on concrete measures regarding water resource development through the support of other donors.

② Expansion and Rehabilitation of Pipes

According to the GIS data, the transmission and distribution pipes throughout Lilongwe City have a total extension of 1,750 km. However, pipes are damaged by water hammer pressure caused by aging or stoppage of water supply at the time of power outage and thus, leakage and suspension of water supply frequently occur. Moreover, asbestos pipes occupy 26.5% (466 km) of the total of the transmission and distribution pipes, which is one of the causes of the insufficient resistance of pipes.

LWB makes the renewal of asbestos pipes the top priority of pipe rehabilitation. Currently, under the support of EIB, the rehabilitation project has been undertaken to replace 18.8 km of the existing asbestos pipes with large-diameter ductile cast iron pipes, in accordance with water demand prediction in 2023.

In addition, LWB plans to rehabilitate 41 km of asbestos pipes with the support of World Bank (hereinafter referred to as "WB)". The existing asbestos pipes totaling 59.6 m will be renewed through these projects, although 406 km of these pipes remain untouched. The Survey Team confirmed that the rehabilitation of these existing pipes will be promoted mainly by WB and detailed survey will be conducted to design duct extension and pipe diameter by consultants hired by WB in 2018.

Table 2-4: Rehabilitation plan for existing asbestos pipes

Unit: km

Zone	Existing Pipes	Rehabilitation Plan			Remaining
		EIB	World Bank*	Total	
North	160.3	8.3	13.1	21.4	138.9
Central	154.2	3.0	12.9	15.9	138.4
South	151.6	7.6	14.9	22.5	129.1
Total	466.1	18.8	40.8	59.6	406.4

* Target Value Before Detailed Design

Source: LWB documents

LWB is also improving its pipe repair system, based on the NRW Reduction Strategy to reduce the physical loss caused by leakage and pipe bursts. The LWB headquarters is equipped with 1,000 polyvinyl chloride pipes (PVC), and Warehouse Section in LWB manages 6,000 water flow meters and replenish their stock appropriately. In FY 2017/18, US 1.5 million dollars were appropriated to repair pipes and LWB is arranging a system to supply and stock pipe materials in order to respond to emergency repairing.

LWB is making progress on concrete measures regarding expansion and rehabilitation of pipes by other donors' support and self-help efforts.

③ Strengthening Financial Capacity

LWB is working on stabilizing the collection of water fee to strengthen its financial capacity, and they plan to install 23,500 pieces of prepaid water meters by 2020 as a measure. At present, it is under the first phase when procurement of 5,000 pieces (1,250 for large users and 3,750 for ordinary customers) is in progress with its own budget (currently in the stage of bidding). In the second phase, 18,500 pieces

(3,500 for commercial and corporate customers and 15,000 for ordinary customers) will be procured under the support of EIB.

LWB is making progress on concrete measures to strengthen financial capacity by other donors' support and self-help efforts.

④ NRW Reduction

LWB shall grasp the amount of NRW accurately to work on its reduction. In Lilongwe, total water supply area is isolated into 106 DMA (District Metered Areas) by LWB and Vitens Evides International (hereinafter referred to as "VEI"). LWB Network Section and GIS Section have updated (GIS databased) the information on existing pipes and valves accordingly, and they have established a system to grasp the status of existing facilities and information on water pressure and flow rate by using pipe-network analysis model (EPANET 2).

Human resource development plays a significant role in NRW reduction and thus, the Technical Cooperation Project of NRW is being implemented in the north region with the aim of fostering caretakers through VEI. On the other hand, in the south region, JICA plans to implement the Technical Cooperation Project of NRW for the purpose of improving a capacity to develop a plan for NRW reduction and technical skills such as installing, repairing, meter reading, leak detection, customer response and public relations.

In addition, LWB has recognized an improvement of work quality as one of the pillars of NRW reduction and hence, they are pursuing the enhancement of quality management through acquiring ISO 9001 and the improvement of customer satisfaction by establishing a customer correspondence system.

Despite the situation that LWB is actively working on NRW reduction and other donors are supporting the activities, the effect of NRW reduction is limited. The limitation results from the lack of equipment for pipe installation; leak management; and management and inspection, in other words, lack of quantity and grade of equipment for NRW reduction. Moreover, t is one of the factor hindering the effectiveness of LWB that their staff members could only deal with issues (pipe exchange, repair and inspection) on a temporary basis because the necessary equipment is not in place.

Based on the above survey results, the equipment procurement for NRW reduction is determined as appropriate. LWB had requested the equipment for pipe installation; leak management; management and inspection; and dredging in the Minutes of Discussions dated 20th of July, 2017. The relevance, effectiveness and sustainability of each component were examined based on the following items.

- To be Identified as prioritized equipment in Simplified Water Supply Plan in Lilongwe City, prepared by the Survey
- To Contribute rolling out the output of the JICA Technical Cooperation Project of NRW
- To Ensure immediate use in the field
- To be agreed with stakeholders to use and have no negative impacts
- To be not affected by contents and schedule of other donors' projects, which either in progress or intend to be implemented

The examination and evaluation results of each equipment component are as follows.

◆ Pipe Installation Equipment

Poor connection of pipes (construction failure) and aged pipes are a major cause of water leakage and it is urgent to connect and repair pipes properly. The procurement of equipment greatly contributes to reduction of NRW.

◆ Leak Management Equipment

Underground leakage is difficult to detect by visual inspection and thus, water utilities tend to be unaware of its existence over a long period. Procurement and utilization of leak management equipment will greatly contribute to the discovery and reduction of underground leakage.

◆ Management and Inspection Equipment

Routine patrol, inspection and communication with customers are necessary, as mentioned in the Strategic Plan to reduce accidents (pipe bursts or water theft) in water facilities, especially pipelines. However, the total length of the city pipe network, managed by LWB, is approximately 1,750 km and thus, LWB staff members end up spending a lot of time doing daily work such as repairing and expanding pipes. They do not have enough time to organize and analyze various work information and formulate countermeasures. Therefore, improving quality management through management and inspection equipment for the facility management greatly contributes to the reduction of NRW rate.

◆ Dredging Equipment (Low Priority)

Dredging equipment is used to dredge the area near the water intake at the water treatment plant to increase the amount of water intake for effective use of water resource (Lilongwe River), as proposed in MGDS II. The equipment is for water resource development although it is acknowledged as an affective countermeasure against NRW because the increased amount of water intake results in increased revenue earning water. Additionally, dredging work is carried out about once or twice a year and it can be done with the heavy machinery (backhoe) owned by LWB. Therefore, the priority of procurement of dredging equipment is evaluated as low.

Furthermore, the relevance, effectiveness and sustainability of a back-up generator were evaluated because they were additionally requested because of the Survey and consultations with the LWB.

◆ Back-up Generator Equipment

Water hammer pressure occurs when the pressure difference inside the water distribution pipe changes greatly due to suspension of water supply at the time of power outage. It damages the aged distribution pipes and contributes to leakage, results in NRW. Furthermore, during the suspension of water supply at the time of power outage, contaminated water flows in from negative pressure pipes where leakage occurs, and subsequently NRW increases due to the removal of contaminated water and pipe cleaning. Large-scale inflow of contaminated water caused by power outage occurred during the Survey, became a significant social issue in Malawi. Thus, ensuring continuous operation even at the time of power outage is effective for protecting pipe network. Maintaining the emergency power supply at the main water supply facilities will greatly contribute to the reduction of NRW.

The equipment for pipe installation; leak management; management and inspection; dredging; and back-up

generator were evaluated, as shown in the table below, based on the following items.

- To be identified as prioritized equipment in Simplified Water Supply Plan in Lilongwe City
- To Contribute rolling out the output of the JICA Technical Cooperation Project of NRW
- To Ensure immediate use in the field
- To have no negative impacts
- To be not affected by contents and schedule of other donors' projects, which either in progress or intend to be implemented

Table 2-5 : Evaluation of component for NRW reduction equipment

Items to be Considered for Appropriateness , Effectiveness and Sustainability of Procurement	Component of NRW Reduction Equipment				
	Pipe Installation	Leak Management	Management and Inspection	Dredging	Back-up Generator
Prioritized Equipment in Simplified Water Supply Plan in Lilongwe City	○	○	○	×	○
Contribution to the Output of the JICA Technical Cooperation Project of NRW	○	○	○	○	○
Immediate Use in the Field	○	○	○	×	○
No Negative Impacts by the Project	○	○	○	○	○
No Impacts by Other Donors' Projects	○	○	○	○	○

Based on the above evaluations, the Project will procure the equipment for pipe installation; leak management; management and inspection; and back-up generator. The purpose of utilizing the equipment is as follows.

Table 2-6: The purpose of utilizing the equipment

Expected Cause of NRW	Components	Purpose of equipment procurement
Construction Failure of Pipe Connection	Pipe Installation	Improvement of Workability
Aged Pipes		Replacing of Aged Pipes
Invisibility of Lakage Point	Leak Management	Visualization of Leakage Point
Misreading of Water Meter	Management and Inspection	Correction of Erroe in Meter Reading
Pipe Brekage due to Power Outage	Back-up Generator	Protection of Pipe Network

The following equipment composition was assumed for each equipment component and the relevance of procurement for each equipment is examined.

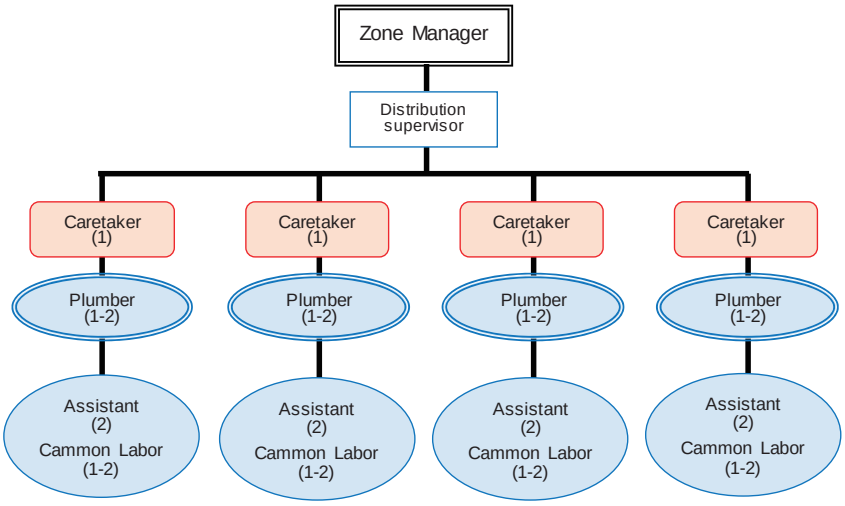
Table 2-7 : Composition of equipment for NRW reduction (before examination)

Components	No.	Item	Purpose of usage
Pipe Installation	101	Pipe Drilling Tools	To drill the side of the transmission pipe
	102	Clamp Saddle	To connect new installed pipe
	103	Pipe Threading Tool	To thread the connection part of galvanized steel pipes
	104	Butte Welding Machine	To connect HDPE pipes
	105	Pipe Cutter	To cut medium or large diameter pipes
	106	Lifting Tools	To hang and fix pipe materials
	107	Small Generator	To supply power at the site
	108	Electric Welding Machine	To connect and repair steel pipes
	109	Tools	For the work at the site
	110	Compactor	To compact the ground at the time of backfilling
	111	Small Excavator	To excavate at the site
	112	Truck with Crane	To transport pipes, pipe materials and the equipment
	113	Engine Pump	To drainage water at the site
	114	Lighting Gear	To project light onto the working area at nighttime
	115	Pipe Repair Clamp and Dresser Joint	To be used as joint portions in repairing and replacing pipes
	116	Medium Tire Type Wheel Excavator	To excavate at the site
	117	Water Pressure Tester	To perform water pressure test
	118	Micro Tunnel Machine	To install pipes by an underground propulsion method
	119	Transporter Truck for Small Excavator	To transport small excavators
Leak Management	201	Leak Detection Tool	To detect invisible points for underground water leakage
	202	Portable Ultrasonic Flowmeter	To measure the flow rate of pipe
	203	Pressure Meter With Data Logger	To measure and record water pressure
	204	Leak Sound Detection Bar	To detect leakage sound
	205	Pipeline Detector	To detect the position of the invisible buried pipe
	206	Portable GPS	To acquire and manage the location information
	207	Pressure Reducing Valve	To maintain the water pressure in the pipeline
Management and Inspection	301	Accuracy Tester of Water Meter	To check the meter reading accuracy
	302	Pressure Gauge for Water Faucet	To check the measure water pressure
	303	Pickup Truck	To transport small excavators, personnel and equipment
	304	Motorcycle	To being used for patrolling along
	305	Service Truck	To carry in and transport a set of equipment to the site
	306	Prefabricated Office	To being utilized as activity office for NRW reduction
Back-up Generator	501	Back Up Generator	To supply power at power failure

2-2-3 Outline Design Drawing

(1) Equipment Suppliers

Daily operation of NRW reduction measures (pipe installation, operation and maintenance, etc.,) is performed by a work team composed of a caretaker as a leader, plumbers, assistant plumbers and common labours at each LWB Zone Offices (North, Central and South). The equipment for the Project will be procured for these work teams as well as Zone Offices.



Role	No. of Peronnel
Caretaker	1
Plumber	1-2
Assistant	2
Common labor	1-2
Total	5-7

Figure 2-1 : Components of a work team

Currently, Network Section has gathered flow measurement and pipeline position information of all pipe networks in Lilongwe City, and the information has been databased by GIS Section. LWB established NRW Reduction Section, consisting of finance, engineering and monitoring and evaluation at the end of 2017, and these staff member will carry out data management of NRW reduction and formulate policies at each Zone Office. The work records and data obtained through the procured equipment will be managd by the Section in the future.

(2) Equipment Planning

Relevance, component and quantity of each equipment to be procured were examined regarding the equipment for pipe installation; leak management; management and inspection; and back-up generator. The water flow meter and the prepaid water meter, which was assumed to be procured before the Survey, were excluded from the equipment procurement due to the following reasons.

◆Water Flow Meter

A flow meter shall be installed at the inflow point of the district-metered area (DMA) in Lilongwe City to grasp the water consumption of each DMA. However, the separation (DMA) has been established at 106 locations by LWB in August 2017, and the installation of water flow meters were almost completed. Hence, it is excluded from the scope of the Project.

◆Prepaid Water Meter

Prepaid water meters shall be installed to prevent of unpaid water charges and alleviate workloads on meter readers. Installation has been already planned for government agencies and large water users initially, and it will be deployed to every door sequentially. LWB has posted a budget of 2.7 million USD in FY 2017/18 and they have procured and installed 5,000 pieces (1,250 pieces for large water users and 3,750 pieces for general customers) in August 2017. Thus, it is excluded from the scope of the Project.

The equipment was divided into “occupied equipment for each work team” and “shared equipment”, and the arrangement and quantity of equipment is examined, based on the frequency and purpose of use for each

work item (pipe installation; leak management; and management and inspection). It is noted that the Project does not post the quantity of equipment, which will be procured by the JICA Technical Cooperation Project of NRW.

The selection process and procurement quantity of each equipment are as follows.

1) Pipe Installation Equipment

◆101 Pipe Drilling Tools (11 Units)

Outline:	Equipment for drilling piping
Purpose of Use:	To drill the side of the transmission pipe in order to branch the water supply pipe from the transmission pipe
Selection History:	The North Zone Office owns one pipe drilling tool as it was donated as a sample by another donor. However, the drilling capacity has declined because the drill bit is worn out. In addition, other Zone Offices do not have pipe drilling tools.
Effect:	More than 80,000 water meters are installed in Lilongwe City and water leakage at the connecting part continuously occurs since pipes were drilled without using specific tools (currently drilled using steel bar). Moreover, the number of connections of water supply pipes has increased. Appropriate use of the pipe drilling tools by all work teams (plumbers) will make the work of branching water supply pipe reliable and effective.
Sustainability:	Sustainable use is expected, as the tools are transportable by the work team (plumbers).
Relevance:	The procurement is highly relevant as it directly contributes to the countermeasure against NRW (pipe installation and repair).
Quantity:	One unit of equipment is schedule to be procured for each work team at each Zone Office. However, one unit is reduced for the South Zone Office because one pipe-drilling tool will be procured through the JICA Technical Cooperation Project of NRW. 1 Unit/Team × 4 Team/Zone Office × 2 Zone Office (North/Central) = 8 Units 1 Unit/Team × 4 Team/Zone Office × 1 Zone Office (South) – 1 Unit (The JICA Technical Cooperation Project of NRW) = 3 Units

◆102 Clamp Saddle (Excluded from the Scope)

Outline:	A pipe material for branching a water supply pipe from a transmission pipe
Purpose of Use:	To facilitate the connection of the water supply pipe when branching off from the distribution pipe
Selection History:	LWB has already voluntarily procured about 6,000 snap taps for new use and repair. Thus, clamp saddles were excluded from the scope.

◆103 Pipe Threading Tool (12 Units)

Outline:	Equipment for threading galvanized steel pipes
Purpose of Use:	To thread the connection part of galvanized steel pipes. Die, which can be threaded

up to 2 inch-diameter pipes, is attached into manual ratchet to thread pipes. It will be used with a tripod fixture to hold the water supply pipe.

Selection History: The pipe threading tool possessed by the Zone Office, is in a state where the threaded portions (dies) are worn and the specified (thread) cannot be cut. Moreover, the quality of pipe junction cannot be maintained because parts corresponding to the caliber are damaged/missing.

Effect: Appropriate use of the pipe-threading tool by all work teams (plumbers) will make pipework reliable and effective

Sustainability: Sustainable use is expected, as it will be a carrying tool for the work team (plumbers).

Relevance: The procurement is highly relevant as it directly contributes to the countermeasure against NRW (pipe installation and repair).

Quantity: One equipment is schedule to be procured for each work team at each Zone Office.
1 Unit/Team × 4 Team/Zone Office × 3 Zone Office (North/Central/South)
= 12 Units

◆104 Butte Welding Machine (Excluded from the Scope)

Outline: Equipment for thermally welding high-density polyethylene pipe (HDPE)

Purpose of Use: To connect HDPE pipes, which are rapidly spreading in African countries in recent years. It is a device to heat and weld the end portion of two pipes, which composed of fusion pressure holder, heating part and hydraulic controller.

Selection History: HDPE pipes installed by LWB has a small caliber (63 mm or less) and mostly coupling connections. Although LWB plans to spread HDPE pipe of medium caliber or larger in the future there is no concrete plan at the moment.

◆105 Pipe Cutter (6 Units)

Outline: Equipment for cutting pipes

Purpose of Use: To cut medium or large diameter pipes such as ductile cast iron pipes by rotating the cutting blade driven by an engine. It will not be used for small diameter of water supply pipes.

Selection History: The Zone Office does not have a pipe cutter, and a cutting machine such as grinder is substituted when cutting pipes on site, even though these machines are not originally made for pipe cutting.

Effect: Appropriate use of the pipe cutter by all work teams (plumbers) will make pipework reliable and effective

Sustainability: Sustainable use is expected, as it is easy to maintain.

Relevance: The procurement is highly relevant as it directly contributes to the countermeasure against NRW (pipe installation and repair).

Quantity: The equipment will be used for medium or large diameter pipes. As it will not be used at all times, it is judged that the procurement of two units (units shared by four

teams) is appropriate for each Zone Office.
2 Unit/Zone Office × 3 Zone Office (North/Central/South) = 6 Units

◆106 Lifting Tools (Chain Hoist and Lever Hoist: 12 Units for Each)

Outline: Equipment for lifting and fixing heavy pipe materials

Purpose of Use: To hang and fix pipe materials when connecting or removing heavy pipes (medium or large diameter pipes and valves)

Selection History: Currently, connecting and removal of heavy pipes are done manually. Thus, water leakage often occurs at the joint portion because the accuracy of gasket installation and bolt fastening is poor during the connecting operation of the flange pipes, which requires careful construction.

Effect: It can also be used for fixing equipment loaded on a vehicle and for repairing existing pumps, etc.

Sustainability: It is easy to transport by vehicle due to its small size, and it can be widely used as an auxiliary tool for work. It can also be used for work other than plumbing such as pump replacement.

Relevance: The procurement is highly relevant as it directly contributes to the countermeasure against NRW (pipe installation and repair).

Quantity: One chain hoist for hanging heavy loads and one lever hoist for lateral direction fixing is schedule to be procured for each work team at each Zone Office. The equipment will be used for medium or large diameter pipes. As it will not be used at all times, it is judged that the procurement of two units (units shared by four teams) is appropriate for each Zone Office.
1 Unit Each/Team × 4 Team/Zone Office ×3 Zone Office (North/Central/South)
= 12 Units for Each Equipment

◆107 Small Generator (11 Units)

Outline: Equipment for supplying power

Purpose of Use: To supply power for electric tools and lightning used for installing and repairing pipes on site. It generates electricity by Dynamo (power generation section) driven by an engine.

Selection History: On site work, it is necessary to secure power supply for electric tools and lightning for night work. However, the generators owned by Zone Offices cannot supply stable power supply due to poor contact, caused by deterioration.

Effect: It is expected to contribute to NRW reduction as the equipment enables the supply of power on site and improves efficiency and security when working at night.

Sustainability: Sustainable use is expected as it will be a tool taken to work sites by the work team (plumbers) and it is easy to transport by vehicle due to its small size.

Relevance: The procurement is highly relevant as it directly contributes to the countermeasure against NRW (pipe installation and repair).

Quantity: One equipment is schedule to be procured for each work team at each Zone Office.

However, one unit is reduced for the South Zone Office because one small generator will be procured through the JICA Technical Cooperation Project of NRW.
1 Unit/Team × 4 Team/Zone Office × 2 Zone Office (North/Central) = 8 Units
1 Unit/Team × 4 Team/Zone Office × 1 Zone Office (South)
– 1 Unit (The JICA Technical Cooperation Project of NRW) = 3 Units

◆108 Electric Welding Machine (3 Units)

Outline:	Equipment for welding
Purpose of Use:	To connect and repair steel pipes and steel brackets beside the bridge
Selection History:	Zone Offices do not own welding machine and thus, they cannot weld steel pipes on site and water feeding pump facility.
Effect:	The equipment can be transported by vehicles, does not require commercial electric power and enables dealing with on-site work quickly. Thus, it is expected to contribute to NRW reduction.
Sustainability:	Sustainable use is expected as it enables welding of pipes on site.
Relevance:	The procurement is highly relevant as it directly contributes to the countermeasure against NRW (pipe installation and repair).
Quantity:	One equipment is scheduled to be procured for each Zone Office, as it is not required for ordinary plumbing. 1 Unit/Zone Office × 3 Zone Office (North/Central/South) = 3 Units

◆109 Tools (12 Sets)

Outline:	Tools for use in piping connection and machine maintenance
Purpose of Use:	To connect and repair pipes, and maintain pipe installation equipment
Selection History:	The work team (plumbers) frequently use deteriorated tools such as pipe wrenches even for the use other than original plumbing. Thus, these tools face a shortage though they need to be carried on site.
Effect:	It can also be used for fixing equipment loaded on a vehicle and for repairing existing pumps, etc.
Sustainability:	Sustainable use is expected, as the tools will be part of those taken to work sites by the work team (plumbers)
Relevance:	The procurement is highly relevant as it directly contributes to the countermeasure against NRW (pipe installation and repair).
Quantity:	One set of tools is scheduled to be procured for each work team at each Zone Office. One set consists of a spanner, screwdriver, box wrench and piping tool such as pipe wrench and will be stored in the easy-to-carry box. 1 Set/Team × 4 Team/Zone Office× 3 Zone Office (North/Central/South) = 12 Sets

◆110 Compactor (Plate Compactor and Hand Compactor: 12 Units for Each)

Outline:	Equipment for compaction
Purpose of Use:	To compact the ground at the time of backfilling of piping work

Selection History: The work team (plumbers) manually makes a compaction and backfilling after the pipe installation. Debris such as rocks, concrete blocks and dirt are not removed and thus water leakage occurs frequently owing to the damage of buried pipe caused by the wheel load of the passing vehicle after the backfilling. Therefore, the equipment needs to be procured to realize sufficient compaction and make workers understand the importance of compacting in earthwork.

Effect: Although appropriate backfilling and compaction is clearly mentioned in LWB technical specifications, it has not been conducted properly because they do not own the equipment. It is the most fundamental and important type of work and the contribution to NRW reduction is expected because of the quality improvement in earthworks by using the equipment.

Sustainability: Sustainable use is expected as it is easy to transport by vehicle due to the small volume of equipment and it will be a tool taken to work sites by the work team (plumbers).

Relevance: The procurement is highly relevant as it directly contributes to the countermeasure against NRW (pipe installation and repair).

Quantity: Compactor can be roughly divided into tamping (impact loading) or vibration (dynamic loading) method. As described above, LWB has conducted compaction without removing debris from the buried soil. Thus, there is a risk of damage to the buried pipe due to erroneous operation of the compactor when using a tamping compactor. Therefore, a vibration compactor such as plate compactor will be procured for the Project because the procurement of a tampered compactor such as a rammer is judged as premature. One engine-type plate compactor and manual hand compactor will be procured for each work team at each Zone Office.

1 Unit Each/Team × 4 Team/Zone Office × 3 Zone Office (North/Central/South)
=12 Units for Each Equipment

◆111 Small Excavator (2 Units)

Outline: Equipment for excavating and discharging earth and sand

Purpose of Use: To excavate narrow routes in distribution and water supply pipelines with appropriate excavation cross section

Selection History: Currently, open-cut method depends on human power, while the excavation range is expanding with an increase of leakage repairing and new pipeline installation. However, manual excavation provides low productivity of excavation volume and thus, it could not secure a proper excavation section. Therefore, crawler type of small excavator is required to access narrow areas and unpaved roads easily and to secure proper excavation cross section quickly.

Effect: It is expected to realize prompt and proper pipe excavation as well as to improve the quality of pipe installation with a shortened work process, which leads to the contribution to NRW reduction.

Sustainability: Sustainable use is expected as it increases the excavation of distribution and water supply pipeline.

Relevance: The procurement is highly relevant as it directly contributes to the countermeasure against NRW (pipe installation and repair).

Quantity: It is necessary for each Zone Office to own the equipment as it enables quick access to the site and carrying out a long-term excavation in a short time. However, one unit of equipment will be procured to the South Zone Office through The JICA Technical Cooperation Project of NRW. Thus, one unit each is appropriate to be procured for the North and Central Zone Office. Although it is a crawler type driven by an engine, it will be transported to the vicinity of the site by transporter truck for small excavator and is to be procured separately.

1 Unit/Zone Office × 2 Zone Office (North/Central) = 2 Units

◆112 Truck with Crane (3 Units)

Outline: Vehicle for loading, unloading and transporting materials with an in-vehicle crane.

Purpose of Use: To load, unload and transport pipes, pipe materials and the equipment for pipe installation

Selection History: Zone Offices do not possess equipment for loading and unloading medium and large-diameter pipe materials and heavy loads, and this is done by human power. Small-sized trucks are used for on-site transportation of long pipe materials. Thus, it is necessary to have a crane-equipped vehicle capable of loading, unloading and quickly transporting pipes and the equipment for pipe installation.

Effect: It can shorten the time taken for pipe installation and repair work, and expand the work area because it enables a small number of people to load, unload and transport heavy loads safely. Thus, it is expected to contribute to NRW reduction.

Sustainability: For on-site work related to pipe repair, installation is expected to increase in the future, and thus, sustainable use of equipment is expected. In addition, all LWB vehicles are equipped with a GPS transmitter, and information such as position running speed is monitored in real time by the LWB headquarters. Thus, the risk of theft or being used for other reasons is low.

Relevance: The procurement is highly relevant as safe and prompt transportation of the water management equipment enables efficient pipe construction and repair work, which greatly contributes to NRW reduction.

Quantity: Carriage of loaded cargo is limited within the Lilongwe City (mainly within the jurisdictional district of each Zone Office) and it is not necessary for the vehicle to stay all day on site with the work team. Thus, one vehicle for each Zone Office is judged appropriate. A hydraulic crane will be mounted on a general-purpose track.

1 Unit/Zone Office×3 Zone Office =Total 3 Units

◆113 Engine Pump (6 Units)

Outline: Equipment for drainage and water injection

Purpose of Use: To drain water when repairing a leak pipe, to wash the inside of a new installed pipe and to fill a pipe with water during the water pressure test. The equipment operates by rotating the impeller type pump driven by an engine.

Selection History: It is necessary to drain water at the time of repairing leakage pipe, wash the inside of a new installed pipe and to fill a pipe with water during the water pressure test.

Effect: It enables prompt filling and drainage of water and is effective against the collapse of excavated cross sectional area caused by water, which leads to the contribution of NRW reduction.

Sustainability: Sustainable use is expected, as it is a general-purpose equipment and can be used for a long time if handled appropriately.

Relevance: The procurement is highly relevant as it can be used for various tests of new pipelines in addition to repairing damaged pipes, which greatly contributes to NRW reduction.

Quantity: It is assumed to be used mainly for repairing pipes with a medium or large diameter and one unit is arranged as one set for each spout size (50 mm and 100 mm). It is appropriate to procure two sets, which are shared by four teams, for each Zone Office as it will not be used at all times. In addition to the main body, a unit includes suction and discharge hose.

2 Sets/Zone Office×3 Zone Office (North/Central/South) = 6 Units

◆114 Lighting Gear (Lighting Gear: 5 Units and Generator Integrated Lighting Gear: 3 Units)

Outline: Equipment for light projector

Purpose of Use: To project light onto the working area when working at nighttime and onto the area inside the pipe or inside the structure

Selection History: Zone Offices do not possess lighting equipment corresponding to pipe bursts or emergency construction occurring at night, which causes troubles for night work. Since the work cannot be carried out until the daytime of the next day, it leads to an increase of the amount of NRW, water supply outages, traffic disruptions and so on while waiting for the construction to commence. Thus, it is necessary to use a light projector to perform work even at night.

Effect: As it can provide nighttime work safely, it is expected to contribute to NRW reduction.

Sustainability: Sustainable use is expected, as night-work is necessary.

Relevance: The procurement is highly relevant as it enables installation and repair pipes regardless of day and night.

Quantity: It is only used for night-work, so each work team does not need to possess the equipment. Thus, two general lighting gears and one engine generator integrated

lighting gear, which can project a wide range, will be procured for each Zone Office and it will be shared with work teams. However, one unit is reduced for the South Zone Office because one lighting gear will be procured through the Technical Cooperation Project of NRW.

Lighting Gear (Total 5 Units):

2 Units/Zone Office × 2 Zone Office (North/Central) =4 Units Each

2 Units/Zone Office × 1 Zone Office (South) – 1 Unit (The Technical Cooperation Project of NRW) =1 Unit

Generator Integrated Lighting Gear (Total 3 Units):

1 Unit/Zone Office × 3 Zone Office (North/Central/South) = 3 Units

◆115 Pipe Repair Clamp and Dresser Joint (A Set)

Outline: Pipe materials for repair and connection

Purpose of Use: To be used as joint portions in repairing and replacing pipes

Selection History: Zone Offices do not have pipe materials for repairing water leakage caused by a partial pipe bursts such as pinholes. At the time of repair, the neighboring pipe network is shut off and pipes, including the front and rear parts, will be replaced. Thus, it takes large amount of workload and time. Furthermore, there are also cases in which chemical pipes such as PVC are joined by heating and deforming the connection port of main pipes because Zone Offices do not have enough jointing materials necessary for replacing pipes. Therefore, pipe materials, which enable repair of pipes quickly and promptly, are necessary. PVC pipes will be procured in FY 2017/18 based on the LWB NRW Reduction Strategy and will be procured continuously from the next fiscal year onwards. However, this strategy does not plan to procure pipe materials for repairing and connecting parts of pipe bursts. Thus, the following pipe materials will be procured: clamp to repair a part of pipe bursts, and dresser joint to insert and connect pipes at the cutting surface of the pipe bursts. The pipe repair clamp is a pipe material, which can repair the pipe damage such as pinholes without replacing pipes and suspending water supply and it is suitable for emergency repair. A dresser joint is a pipe material that connects a new replacement pipe and an existing pipe when replacing a part of a broken pipe (crack, joint, etc.). It allows the pipe exchange range (distance) and exchange time to be shortened. In addition, it is possible to attach and detach easily because it is connected by tightening the rubber rings with bolts and nuts. Thus, it can be diverted unless deterioration of the joint is noticed. The target pipe type is PVC pipe (70% of the total pipe length) with the longest laying extension in Lilongwe City. Regarding asbestos pipes (27% of total length), pipe extension and pipeline rehabilitation have been implemented by the EIB and in addition, pipeline rehabilitation project by WB is planned. Therefore, it was excluded from the target of the Project.

Effect: It is expected to be effective for NRW reduction (reduction in pipe construction

failure) because the pipe material enables prompt and appropriate rehabilitation of pipes. Furthermore, it can contribute to the achievement of the Technical Cooperation Project of NRW.

Sustainability: Sustainable use is expected as LWB recognizes the importance of rapid and proper pipe repair. In addition, LWB aims to complete the suspension of water supply owing to leakage and pipe bursts within 30 minutes, and to complete pipe repair within 2 days, as described in the NRW Reduction Strategy.

Relevance: The procurement is highly relevant as it enables contribution to reducing water leakage.

Quantity: PVC pipes (pipe diameters: 160 mm, 110 mm and 63 mm) occupying 64% of the total length is the target. Other pipes were excluded from the target for the Project because other pipes with short length or pipes with a dimeter that requires about several dozen will be used less frequently.

LWB has been repairing pipes at a frequency of 500 to 1,000 m /point. Clamp will be effectively used to repair partial pipe bursts such as pinhole bursts; this type of breakdown are presumed to occur at frequency of 800 m/point. On the other hand, joints will be effectively used to replace pipes where cracking occur; it is presumed to happen at frequency of 1000 m/point. Based on the above assumption, the repair point at the entire length of target pipe was calculated.

Table 2-8 : Repair spot according to pipe diameter

Pipe Type	Diameter (mm)	Total Length of Pipes (km)	Partial Pipe Repair (m/place)	Pipe Replace (m/place)	Repair Place	
					Partial Pipe Repair (Repair Clamp)	Pipe Replace (Dresser Joint)
		①	②	③	④=①÷②	⑤=①÷③
PVC	160	210.86	800	1,000	263	210
	110	386.08	800	1,000	482	386
	63	519.05	800	1,000	648	519
Total		1,115.99	—	—	1,393	1,115
					2,508	

LWB conducts pipe repair work 600 times (=50 times × 4 weeks × 3 offices) every month for all installed pipes. The number of repair points targets PVC pipe, which occupies 64% of the total length. Thus, it is assumed that the number of repair works for target area will be 384 times (=600 times × 64%). Assuming that 50% of the work will require pipe repair clamps and dresser joints, the number of repair works using the procured pipe material is about 2,300 times annually (=384 times × 12 months × 50%). Hence, the number of repair points mentioned above (2,508 points) will be completed in about one year. From the next fiscal year onwards, it is expected that the frequency of repair works will decrease, while similar repair works are presumed to occur to some extent. At the same time, the number of water leakage repairs for underground will be increased as newly procured equipment become possible to detect water leakage in the invisible part. Thus, the similar number of repair

points is assumed to occur in the next and subsequent years. As the target year of equipment use is 3 years after the procurement, pipe materials, required to repair the triple number of annual repair points (2,508 points) will be procured for the Project. The quantities of repair clamps and dresser joints are as follows.

Table 2-9 : Planned quantity of pipe repair clamps / dresser joints

Pipe Type	Diameter (mm)	Annual Repair Place (place/year)		Planned Number of Equipment to be procured (piece/place/3 years)	
		Partial Pipe Repair	Pipe Replace	Partial Pipe Repair (Repair Clamp)	Pipe Replace (Dresser Joint)
		①	②	③＝①×3	④＝②×3
PVC	160	263	210	789	630
	110	482	386	1,446	1,158
	63	648	519	1,944	1,557
Total		1,393	1,115	4,179	3,345

In pipe replacement, a joint is needed at each end, to attach the new replacement pipe to the insertion opening at both ends of the existing pipe. However, one joint can repair the pipe when a replacement pipe, which has as a socket or entrance at one end, is used. Therefore, the number of joints is planned at one piece/point.

◆116 Medium Tire Type Wheel Excavator (Excluded from the Scope)

Outline: Equipment for excavating deep soil and filling it back

Purpose of Use: To drill at the time of embedding a pipeline of medium size or more such as main transmission and distribution pipe

Selection History: LWB has two wheel loaders with backhoes at the rear of the body as a deep excavating machine. The machine can drill more than 4 m with the bucket capacity of about 0.2 m^3. The operation time is about 5,000 hours and it is an operable condition. Thus, it is excluded from the scope.

◆117 Water Pressure Tester (3 Units)

Outline: Equipment for inspecting leakage of newly built pipeline

Purpose of Use: To perform water pressure test during water leakage inspection. It will pressurize the interior of the pipe to the specified water pressure, and measure the pressure for a specified time after cleaning the inside of the pipeline with the engine pump and fill the hydraulic test water.

Selection History: It is fundamental to perform washing before water supply, hydraulic pressure test and pipe disinfection in order to prevent contamination of foreign matters and leakage. However, LWB has not operated these works sufficiently and thus, the following accidents occur; water pollution caused by contamination of foreign matters and leakage due to poor pipe connection. The equipment is necessary to perform water pressure test.

Effect: Appropriate implementation of hydraulic pressure test is specified in LWB technical

specification. As it enables grasp of pipeline water pressure, it is expected to contribute to NRW reduction.

Sustainability: Sustainable use is expected, as it is general-purpose equipment and is possible to use for a long time if handled properly.

Relevance: The procurement is highly relevant as measures to prevent pipe bursts contribute to NRW reduction.

Quantity: One set of the equipment for each Zone Office is appropriate because it will not be used at all times. Besides the main body, the following devices are included: connection and pressure-resistant hoses, and a drainer, which is for plugging both ends of the pipe to be tested at the time of water pressure test, and connecting to the pressurizing engine pump and water pressure gauge.
1 Unit/Zone Office×3 Zone Office (North/Central/South) = 3 Units

◆118 Micro Tunnel Machine (Excluded from the Scope)

Outline: Equipment for excavating underground

Purpose of Use: To install pipes by an underground propulsion method at intersections where open-cut method is difficult.

Selection History: Open-cut method at the crossing point of the main road with heavy traffic causes traffic restrictions such as vehicle detouring, and thus it has a great impact on traffic. Underground propulsion method does not have much impact on traffic and contributes to the reduction of the construction cost and period. However, pipeline network of Lilongwe City has few crossing points at main roads and it is possible to carry out open-cut method depending on prior investigation and places. Considering the burdens on economy and human resources such as special operation, equipment price, operation and maintenance expenses and operating labor costs, the cost-effectiveness of procurement is low. Commissioning to external specialized companies can also be considered. Thus, the equipment was excluded from the scope.

◆119 Transporter Truck for Small Excavator (3 Units)

Outline: Vehicles for transporting small excavators

Purpose of Use: To transport small excavators, personnel and equipment

Selection History: It is not possible for ordinary four-wheel vehicles (pick-up trucks) to draw and transport small excavators due to the strength of the vehicle since total weight of small excavators is 3 to 3.7 tons. Thus, the vehicle is required to transport a small excavator safely and quickly.

Effect: It is expected to shorten the time taken for transportation and conveyance when installing and repairing pipes and to expand the working area, by allowing the transportation of personnel and equipment as well as small excavators. In addition, it has a mechanism that can tilt the body itself with a high outrigger and it enables a small excavator to get on and off safely. Thus, it is expected to reduce transport

accidents.

Sustainability: On-site work related to repairing and installing pipes is expected to increase in the future, and sustainable use is expected. In addition, all LWB vehicles are equipped with a GPS transmitter, and information such as position running speed is monitored in real time by the LWB headquarters. Thus, the risk of theft or being used for other purposes is low.

Relevance: The procurement is highly relevant, as LWB does not own trucks for transporting a small excavator.

Quantity: One set of the equipment for each Zone Office is appropriate. General-purpose trucks are mounted with a cargo bed that can carry small excavator and a high outrigger on the front of the vehicle. In addition to the vehicle body, it also includes a loading ramp for carrying a small excavator.

1 Unit /Zone Office × 3 Zone Office (North/Central/South) =3 Units

2) Leak Management Equipment

◆201 Leak Detection Tool（Correlation Formula: 2 Units and Sound Hearing: 5 Units）

Outline: Equipment for detecting underground water leakage

Purpose of Use: To detect invisible points for underground water leakage

Selection History: Zone Offices do not have leak detectors. Thus, it is necessary to detect underground leakage, which is one of the causes for NRW.

Effect: It can be expected to be effective for NRW reduction as it becomes possible to discover invisible water leakage.

Sustainability: Sustainable use is expected since it is possible to be used for a long-term, if handled properly. In addition, the JICA Technical Cooperation Project of NRW will help to ensure the sustainability of equipment use.

Relevance: The procurement is highly relevant as it contributes to NRW reduction (leakage grasp).

Quantity: With regard to water leakage detection, there is “correlation formula” which detects the leakage in contact with the pipe body and “sound hearing” which detects the leakage in non-contact with the pipe body (metal part). In the case of the correlation formula, the distance of the contact part (metal part such as the valve and fire hydrant) affects detection accuracy. In the case of sound hearing type, the road surface condition such as paved and unpaved greatly affects detection accuracy. Therefore, a correlation formula and a sound hearing of detector will be procured in order to select an advantageous method under various conditions such as road surface and contact part.

Table 2-10 : Comparison of leakage detection type

Type of Detection	Road Surface Condition	Contact with Pipe Body	Affect of Noise	Affect of Weather
Correlation Formula	All Road	Necessary	Few	None
Sound Hearing	Paved Road	Not necessary	Large	Affect

Work team at the Zone Office (4 Teams) will shorten the time of daily repair work for distribution pipe and spend time on leakage management work by utilizing procurement equipment. However, procurement of one unit for four teams is appropriate because the repair work for distribution pipe is prioritized. Although leakage detection tools are required for each Zone Office, the South Zone Office will be provided with one correlation formula and one sound listening type through the Technical Cooperation Project of NRW. It is effective to detect by multiple units of sound hearing at South area because it has the highest water leakage rate with many paved roads. Therefore, it is appropriate to procure three units separately from the JICA Technical Cooperation Project of NRW for the South Zone Office in order to establish a wide detection system.

Correlation Formula Detector (Total 2 Units):

1 Unit / Zone Office × 2 Zone Offices (North/Central) = 2 Units

Sound Hearing Detector (Total 5 Units):

1 Unit / Zone Office × 2 Zone Offices (North/Central) = 2 Units

3 Units / Zone Office × 1 Zone Office (South) = 3 Units

◆202 Portable Ultrasonic Flowmeter (Excluded from the Scope)

Outline: Equipment for measuring flow rate in pipe

Purpose of Use: To measure the flow rate of pipe at an optional section externally

Selection History: LWB holds about 15 ultrasonic water flow meters provided by other donors. Therefore, it is excluded from the scope.

◆203 Pressure Meter With Data Logger (4 Units)

Outline: Equipment for measuring water pressure of pipe.

Purpose of Use: Connect to optional pipeline and measure and record water pressure

Selection History: A large water pressure fluctuation (30 m or more) of the pipe water pressure occurring throughout the day and night is a cause of pipe leakage. Therefore, it is essential to measure and grasp the current water pressure because pressure-reducing valve to suppress water pressure fluctuation needs to be installed.

Effect: It is expected to be effective for NRW reduction as it is possible to measure the water pressure inside of the pipe.

Sustainability: Sustainable use is expected because it will be used for a long-term if handled properly. In addition, the JICA Technical Cooperation Project of NRW will help to ensure the sustainability of equipment use.

Relevance: The procurement is highly relevant as it contributes to NRW reduction (understanding of water pressure inside the pipe).

Quantity: Two units (2 units shared by 4 teams) are considered as appropriate for each Zone Office. Although a pressure meter is necessary for each Zone Office, 10 units of data logger will be provided to the South Zone Office through the JICA Technical Cooperation Project of NRW. Therefore, two units are appropriate for the North and

Central Zone Offices excluding the South Zone Office.

2 Units / Zone Office × 2 Zone Offices (North/Central) = 4 Units

◆204 Leak Sound Detection Bar (Analog and Digital type: 11 Units Each)

Outline: Equipment for sensing water leakage sound inside pipeline.

Purpose of Use: To detect leakage sound by applying the equipment directly to the pipe.

Selection History: Zone Offices do not have leak detection equipment (leak sound detection bar). Thus, it is necessary to be able to detect underground leakage, which is one of the causes for NRW.

Effect: It is expected to be effective for NRW reduction as it is able to discover invisible leakage.

Sustainability: Sustainable use is expected because it will be used for a long-term, if handled properly.

Relevance: The procurement is highly relevant as it contributes to NRW reduction (grasps water leakage).

Quantity: In addition to ordinary work for detecting leakage, the equipment is also utilized for listening to sound around water meter of individual customers' water meter, at the time of repair work for distribution pipe. It is planned to use "analog type" suitable for listening to the sound of buried pipes and valves and "digital type" suitable for listening to the sound of the ground exposed parts around water meter of individual customers.

Table 2-11 : Comparison of type for Leak sound detection bar

Type	Detection Target	Contact Distance	Detection Difficulty
Analog type	Buried Pipes and Valves (Pipes, valves, flowmeters, etc.)	About 1.5 m	Difficult (Audibility)
Digital type	Exposed Parts (Water meter of individual customers, etc.)	About 0.3 m	Easy (Digital)

Although leak sound detection bars are necessary for each work team, the South Zone Office will be provided with one analog type and one digital type through the Technical Cooperation Project of NRW. Therefore, the number of procurements will be decreased.

Analog type (Total 11 Units):

1 Unit/Team × 4 Team/Zone Office × 2 Zone Office (North/Central) = 8 Units

1Unit /Team × 4 Team/Zone Office × 1 Zone Office (South) - 1 Unit (the Technical Cooperation Project of NRW) = 3 Units

Digital type (Total 11 Units):

1 Unit/Team × 4 Team/Zone Office × 2 Zone Office (North/Central) = Total 8 units

1 Unit/Team, × 4 team/Zone Office × 1 Zone Office (South) – 1 Unit (The Technical Cooperation Project of NRW) = 3 Units

◆205 Pipeline Detector (2 Units)

Outline: Equipment for detecting the position of buried pipe

Purpose of Use: To detect the position of invisible buried pipe

Selection History: Early detection of underground leakage, replacement of pipe installation, ordinary operation and management is hindered because there are many pipelines where the locations of buried pipes are unknown.

Effect: It is expected to be effective for NRW reduction as it enables detection of the position of all types of pipes, including asbestos pipes.

Sustainability: Sustainable use is expected because it will be used for a long-term, if handled properly. In addition, the JICA Technical Cooperation Project of NRW will help to ensure the sustainability of equipment use.

Relevance: The procurement is highly relevant as it contributes to NRW reduction (Establishment of plan for pipe repair and rehabilitation).

Quantity: One procurement is appropriate for each Zone Office, as it is not used at all times. Although pipeline detectors are necessary for each Zone Office, one is to be provided to the South Zone Office through the Technical Cooperation Project of NRW. Therefore, two units are appropriate for the North and Central Zone Offices excluding the South Zone Office.
1 unit / Zone Office × 2 Zone Offices (North / Central) = 2 Units

◆206 Portable GPS (Excluded from the Scope)

Outline: Equipment for acquiring position information

Purpose of Use: To acquire and manage the location information of water facilities

Selection History: LWB holds about 20 GPSs provided by other donors. Therefore, portable GPS was excluded from the scope.

◆207 Pressure Reducing Valve (Excluded from the Scope)

Outline: A pipe material for reducing the excess water pressure inside the pipe.

Purpose of Use: To maintain the water pressure in the distribution and transmission pipe

Selection History: Water pressure fluctuation difference (over 30 m) occurring day and night is one of main causes of water leakage. Appropriate water pressure is an urgent task to be taken and the situation allows for no delay of procurement, scheduled in 2019 for the Project. Accordingly, LWB has a pressure-reducing valve through its own funds and is currently working on the installation of the device. Therefore, it is excluded from the scope.

3) Management and Inspection Equipment

◆301 Accuracy Tester of Water Meter (6 Units)

Outline: Equipment for checking the accuracy of the water meter

Purpose of Use: To check the meter reading accuracy by comparing the flow rate between pipe and the water meter (for house connection).

Selection History: As a cause of NRW, the error of meter reading in water consumption is mentioned and it is necessary to check the accuracy of each water meter.

Effect: As it enables checking of the accuracy of water meter, it is expected to contribute to NRW reduction.

Sustainability: LWB is fully aware of the influence on non-revenue water from meter reading errors of water meters and illegal connections (remodeling). Thus, sustainable use is expected, and furthermore, the implementation of The JICA Technical Cooperation Project of NRW will help to ensure the sustainability of equipment use.

Relevance: The procurement is highly relevant as it directly contributes to NRW reduction (improvement in meter reading accuracy of the water meter).

Quantity: Two units of the equipment for each Zone Office are appropriate.
2 Units/Zone Office×3 Zone Office (North/Central/South) = 6 Units

◆302 Pressure Gauge for Water Faucet (20 Units)

Outline: A pipe material for measuring water pressure

Purpose of Use: To measure water pressure on the water supply pipe at all times

Selection History: Large hydraulic pressure fluctuation (30 m or more) for the pipe occurring throughout the day and night is one of the causes of pipe leakage. Thus, it is necessary to measure the water pressure throughout the pipeline network and to have a water pressure gauge that keeps the proper water pressure.

Effect: As it enables grasping of the water pressure of the pipeline network (terminal part), it is expected to contribute to NRW reduction.

Sustainability: Sustainable use is expected, as it is a general-purpose equipment and can be used for a long time if handled appropriately. In addition, the implementation of The JICA Technical Cooperation Project of NRW will help to ensure the sustainability of equipment use.

Relevance: The procurement is highly relevant as it directly contributes to NRW reduction (management of water pressure).

Quantity: Ten units of the equipment for each Zone Office are appropriate. Although pressure gauges for water faucets are necessary for each Zone Office, 10 units of equipment will be procured to the South Zone Office through The JICA Technical Cooperation Project of NRW for NRW reduction. Therefore, it is considered that procurement of 10 units is appropriate for the North and Central Zone Offices excluding the South Zone Office.
10 Units /Zone Office×2Zone Office (North/Central) = 20 Units

◆303 Pickup Truck (Excluded from the Scope)

Outline: Vehicles for personnel, equipment and small excavators

Purpose of Use: To transport small excavators, personnel and equipment

Selection History: Initially, procurement of a truck that pulled a towing vehicle loaded with a small excavator in addition to the transportation of personnel and equipment was considered. However, pulling and transporting a small excavator (3 to 3.7 tons) by a

pickup truck is not safe enough in terms of strength of the vehicle and safety of transportation. In addition, each Zone Office owns and operates eight (8) pickup trucks. Thus, it is excluded from the scope.

◆304 Motorcycle (6 Units)

Outline: Vehicle for transporting personnel

Purpose of Use: To be used for patrolling along the distribution and water supply pipes and meter reading and inspection of the water meter

Selection History: Although LWB has about 22 motorbikes, more than half are for paved roads (road bikes). The operation rate of vehicles for unpaved roads (off-road motorcycles) is low because most of them are either under repair or out of order due to low quality and intensive use of the vehicles. Thus, the motorcycles with flexibility and durability are necessary to patrol along distribution and water supply pipes, which are installed in the unpaved roads with high unevenness, and to measure and inspect water meters installed at about 80,000 places.

Effect: Proper fee collection is expected through the wide area of patrol and surveillance, which is effective for reducing NRW. It also contributes greatly to a prompt customer response, which is one part of the Strategic Plan 2015-2020 of LWB.

Sustainability: Sustainable use is expected, as the following on-site work will be increased: patrolling along water points of each door, which can be only accessed through the narrow unpaved road, and measuring water pressure. In the future, GPS monitoring and management system for information on vehicle position and traveling speed will be introduced for two-wheeled vehicles. Thus, the risk of theft or being used for other purposes is low.

Relevance: The procurement is highly relevant as a means of transportation with flexibility is necessary for patrolling and monitoring areas with many unpaved and narrow parts.

Quantity: Each Zone Office has five (5) vehicles for personnel in charge of customer care service including meter reading (about 4 to 5 people). Thus, two units for each Zone Office are appropriate.

2 Units/Zone Office×3 Zone Offices (North/Central/South) = 6 Units

◆305 Service Truck (Excluded from the Scope)

Outline: Vehicles for carrying in pipe materials, equipment, and transporting to the site

Purpose of Use: To carry in and transport a set of equipment to the site for repair work on the site

Selection History: Inadequate equipment and materials decrease work efficiency when installing and repairing pipes on the site. Thus, the necessity of a vehicle for carrying a set of pipe installation equipment has been considered. However, the size of generators, compactors and joint parts of pipes is relatively large and it cannot be stored or transported by general vehicles. Meanwhile, “Truck with crane” which is separately procured, satisfies the load weight and volume requirements. It is possible to transport a long (6 m) pipe, load and unload heavy loads using an in-vehicle crane.

Therefore, service trucks are excluded from the scope.

◆306 Prefabricated Office (Excluded from the Scope)

Outline: Room for office and meeting

Purpose of Use: To be utilized as activity office against NRW reduction and storage for pipes and materials

Selection History: The JICA Technical Cooperation Project of NRW will be implemented at the South Zone Office. However, the office is not spacious enough for project experts and counterparts to work and conduct the meeting and training. Thus, it is required to expand the office and conference room.

Effect: It is effective for reducing NRW because sharing the working place among project experts and counterparts will lead to the promotion of information sharing and communication, which contributes to rolling out the output of the JICA Technical Cooperation Project of NRW.

Sustainability: Sustainable use is expected even after the JICA Technical Cooperation Project of NRW, because LWB plans to increase personnel as described in the NRW Reduction Strategy.

Relevance: As one part of the Strategic Plan 2015-2020, LWB has a plan to set up an additional office with an eye on future increases of personnel and equipment. In FY 2017/18, about 300 thousand US dollars will be posted as an additional budget; the budget for the next fiscal year is also expected. In addition, it is possible for an on-site office to be constructed with building specifications, construction method (construction cost), and materials (unit price) in Malawi, and thus it is possible to expand the office at a lower price in a shorter period than procuring from the Japanese market. Thus, the prefabricated office was excluded from the scope.

4) Back-up Genetator Equipment

◆501 Back Up Generator (1 Unit)

Outline: Equipment for supplying power

Purpose of Use: To supply power to water supply pumps and pumps for water treatment plant during power failure

Selection History: Power shortage is one of the major issues in Malawi, and planned blackouts are being carried out on a daily basis in Lilongwe City. Operation of water purification facility and water supply pump are suspended due to power failure. Suspension of water supply during power outage causes water hummer due to changes in water pressure of pipeline. This leads to the bursts and leakage of aging pipelines as well as the inflow of contaminated water from outside. Thus, it is necessary to supply power by a back-up generator that allows constant water supply even at the time of power failure.

Effect: The physical burden on the aged pipe due to suspension of the operating pump of

transmission line is substantial. Maintaining water delivery even at the time of power outage reduces the load (damage risk) to the pipe and is effective for reducing the NRW. In addition, LWB plans to secure alternative power at the time of power outage as an issue in the Infrastructure Investment Plan (mid-term plan). Nevertheless, there is no prospect of procuring funds so far and thus, the effect of securing the back-up power supply is great.

Sustainability: It is possible to budget the operation cost (fuel cost) of the generator since LWB plans to investigate and construct alternative power sources as described in the Infrastructure Investment Plan. Operation and management of the generator is limited to the replacement of the regular oil filter and the air filter, and expert knowledge is unnecessary. Therefore, sustainable use is expected.

Relevance: In addition to the inspection and construction of the alternative power supply mentioned above, the power supply situation will be improved by the Project for Improvement of Substations in Lilongwe City. Thus, it is not reasonable to install a back-up generator for all pump facilities. However, the Southern region has a higher NRW ratio than other regions. Damage and deterioration of piping are one cause of NRW; while reducing the physical burden on existing pipes such as damage risk of water hammer caused by power outage has greatly contributed to the reduction of NRW. The Mwenda Booster Pump Station is a key point for all water supply from TW-I water treatment plant in the South region and thus, the priority is high. Two distribution reservoir tanks (2,000 m^2 and 2,275 m^2) are located in the same site and each reservoir can deliver water even if the water supply is suspended at the time of power outage. It is located at the South Zone Office and daily operation and LWB staff members can easily conduct maintenance. Thus, it is appropriate to install a back-up generator at the Mwenda Booster Pump Station. In the Mwenda Booster Pump Station, 8 water pumps (rated output of motor: 55 to 132 kW) are installed to 3 water transmission pipes, and 5 of them (the other 3 pumps are for standby) are in normal operation. The capacity of the emergency generator is assumed to operate these five pumps, and is planned with 700 kVA, which is the most efficient operation based on the striking current of the pumps (motors), the starting method, the starting order, etc.

Quantity: It is considered appropriate to install the equipment in the Mwenda Booster Pump Station at the South Zone Office in order to satisfy the following conditions; (i) Reduction of damage, leakage and contaminated water of aged pipelines, (ii) Effects of the Infrastructure Investment Plan and (iii) an Area with the highest NRW ratio
1 Unit /Zone Office × 1 Zone Office (South) =Total 1 Unit

Based on the above examination results, the following equipment procurement for the Project will be planned and arranged appropriately.

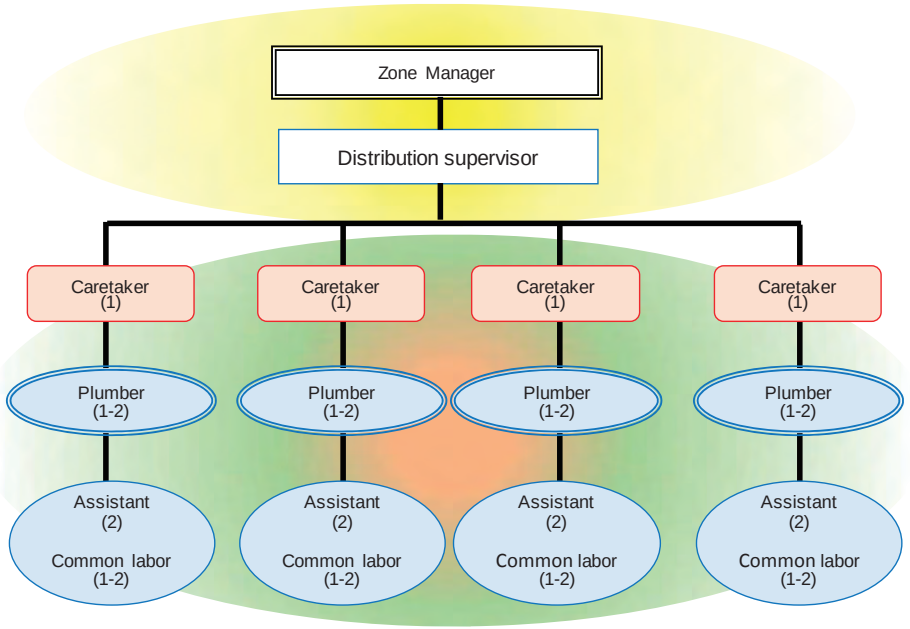
(3) Design Plan for Replacement and Consumable Goods

The Project will procure a year's worth of consumable goods for procured equipment.

Table 2-12 : Composition of equipment for NRW reduction (after the examination)

Component	No.	Item	Quantity	Procurement breakdown
Pipe Installation	101	Pipe Drilling Tools	11 Units	North・Central×4 Units、South×3 Units
	103	Pipe Threading Tool	12 Units	North・Central・South×4 Units
	105	Pipe Cutter	6 Units	North・Central・South×2 Units
	106	Lifting Tools		
		●Chain Hoist	12 Units	North・Central・South×4 Units
		●Lever Hoist	12 Units	North・Central・South×4 Units
	107	Small Generator	11 Units	North・Central×4 Units、South×3 Units
	108	Electric Welding Machine	3 Units	North・Central・South×1 Unit
	109	Tools	12 Sets	North・Central・South×4 Sets
	110	Compactor		
		●Plate Compactor	12 Units	North・Central・South×4 Units
		●Hand Compactor	12 Units	North・Central・South×4 Units
	111	Small Excavator	2 Units	North・Central×1 Unit
	112	Truck with Crane	3 Units	North・Central・South×1 Unit
	113	Engine Pump	6 Sets	North・Central・South×2 Sets
	114	Lighting Gear		
		●Generator Integrated Lighting Gear	3 Units	North・Central・South×1 Unit
		●Lighting Gear *	5 Units	North・Central×2 Units、South×1 Unit
	115	Pipe Repair Clamp and Dresser Joint		
		●Pipe Repair Clamp	4,179 Pieces	ND63×1944、ND110×1446、ND160×789
		●Dresser Joint	3,345 Pieces	ND63×1557、ND110×1158、ND160×630
	117	Water Pressure Tester	3 Sets	North・Central・South×1 Set
	119	Transporter Truck for Small Excavator	3 Units	North・Central・South×1 Unit
Leak Management	201	Leak Detection Tool		
		●Correlation Formula	2 Units	North・Central×1 Unit
		●Sound Hearing	5 Units	North・Central×1 Unit、South×3 Units
	203	Pressure Meter With Data Logger	4 Units	North・Central×2 Units
	204	Leak Sound Detection Bar		
		●Analog type	11 Units	North・Central×4 Units、South×3 Units
		●Digital type	11 Units	North・Central×4 Units、South×3 Units
	205	Pipeline Detector	2 Units	North・Central×1 Unit
Management and Inspection	301	Accuracy Tester of Water Meter	6 Units	North・Central・South×2 Units
	302	Pressure Gauge for Water Faucet	20 Pieces	North・Central×10 Pieces
	304	Motorcycle	6 Units	North・Central・South×2 Units
Back-up Generator	501	Back Up Generator	1 Unit	Mwenda Booster Pump Station (South) ×1 Unit

*The Project will procure a year's worth of consumable goods for procured equipment.



No.	Item	North	Central	South	Total
111	Small Excavator	1	1	0	2
112	Truck with Crane	1	1	1	3
119	Transporter Truck for Small Excavator	1	1	1	3
304	Motorcycle	2	2	2	6
501	Back Up Generator*	0	0	1	1

* No.501 is installed at Mwenda Booster Pump Station within the site of the South Zone office.

No.	Item		North	Central	South	Total
101	Pipe Drilling Tools		4	4	3	11
103	Pipe Threading Tool		4	4	4	12
105	Pipe Cutter		2	2	2	6
106	Lifting Tools	Chain Hoist	4	4	4	12
		Lever Hoist	4	4	4	12
107	Small Generator		4	4	3	11
108	Electric Welding Machine		1	1	1	3
109	Tools		4	4	4	12
110	Compactor	Plate Compactor	4	4	4	12
		Hand Compactor	4	4	4	12
113	Engine Pump		2	2	2	6
114	Lighting Gear	Lighting Gear	2	2	1	5
		Generator Integrated Lighting Gear	1	1	1	3
115	Pipe Repair Clamp and Dresser Joint	Pipe Repair Clamp	It is kept at LWB HQ and allocated to Zone offices as necessary.			
		Dresser Joint				
117	Water Pressure Tester		1	1	1	3
201	Leak Detection Tool	Correlation Formula	1	1	0	2
		Sound Hearing	1	1	3	5
203	Pressure Meter With Data Logger		2	2	0	4
204	Leak Sound Detection Bar	Analog type	4	4	3	11
		Digital type	4	4	3	11
205	Pipeline Detector		1	1	0	2
301	Accuracy Tester of Water Meter		2	2	2	6
302	Pressure Gauge for Water Faucet		10	10	0	20

*The Project will procure a year's worth of consumable goods for procured equipment.

Figure 2-2 : Placement plan of each equipment

2-2-4 Implementation Plan

2-2-4-1 Implementation Policy

(1) Basic Policy

The Project is implemented in accordance with the scheme of Japanese Grant Aid. Grant Aid is provided based on Exchange of Notes (hereinafter referred to as "E/N") that Goverment of Japan (hereinafter referred to as "GoJ") and Malawi approved and exchanged, specifying the purpsoe and excecuting agency of the project, and the terms and amount of Grant. Following the E/N, a Grant Agreement (hereinafter referred to as "G/A") is to be concluded between JICA and Malawi to define the terms of payment, the responsibilities of Malawi Government and the terms of procurement. For details of procedures for procurement under Grant Aid, agreement is made between JICA and Malawi at the event of signing E/N and G/A. JICA stands in a position to promote appropriate implementation of the Projects, and products and services are procured/provided according to the scheme of Grant Aid.

(2) Procurement Method

In principle, funds for Grant Aid shall be used to purchse the products of Japan or recipient countries as well as the services of the Japanese citizens or recipients. The funds for Grant Aid are provided for purchase of products or services from third countries (other than Japan or recipient countries) in case where GoJ and the government of recipient countries (or authorities designated by the government) approved their neccessity. However, the prime contractors required for implementing Grant Aid, namely consultant and procurement agents, are limited to "Japanese citizens". In principle, procurement agents shall be selected by competitive bidding and thus, unfairness will not arise between bidders who are eligible to procure products and services. Bidding documents are prepard by consultants in consultation with Malawi.

(3) Implementation Structure of the Recipient Country

The responsible and executing agencies of Malawi for the Project are MAIWD and LWB. Consultants, procurement agencies and related agencies of Malawi shall contact and consult each other closely in order to promote the Project smoothly. The responsible and executing agencies of Malawi shall appoint a responsible person in charge of the Project.

(4) Consultant

1) Operation before the start of Bidding

The consultant reviews the work carried out in the Preparatory Survey and results of the Survey. In addition, bidding documents will be prepared after the review and need to be approved by GoM to keep the work consistent.

2) Operation at the Bidding stage

At the stage of bidding, the consultant carries out the following operations.

- Compile and prepare bidding documents (mainly technical specifications)
- Hold a bid opening
- Prepare to answer questions and addenda of bidding documents
- Conduct bid evaluation and prepare the evaluation sheet and report

- Assist contract negotiations

3) Operation at Procurement Supervision Stage

The consultant needs to confirm whether the equipment shipped from the procurement agency is compliant with the requested specifications and quantities, and whether it is properly installed, during procurement supervision. When the equipment requires initial operation guidance, the consultant needs to be present and supervise the smooth implementation of the guidance.

(5) Procurement Agent

In accordance with Japan's Grant Aid framework, a Japanese corporation shall be the procurement agency, selected through public open bidding, and shall provide equipment and services neccessary for the Project and procure the equipment, after concluding a contract. They shall fully consider the communication and adjustment because after-service is considered necessary after the completon of equipment procurement.

2-2-4-2 Implementation Conditions

(1) Space for the Equipment to be Procured

Malawian side shall secure the space to accept procured equipment by the time the equipment arrives.

(2) Implementation of Tax Exemption

The following items shall be prepared by LWB in advence to receive tax exemption for the Project: a letter to the Malawi Revenue Authority (MRA) applying for the "Free Status" of Value Added Tax (VAT) and Customs Duty; the G/A; a copy of the contracts with the contractors; and Bill of Quantities, showing the list of procured equipment. These documents need to be submitted through the principal secretary of MAIWD to Malawi Revenue Authority (hereinafter referred to as "MRA"). It takes approximately a month for application to be approved. Thus, MAIWD and LWB shall proceed the application process immedeately after the equipment leaves the port of load in order to shorten the time taken for the procedure at bonded area (either boarders between Mozambique and Malawi or dry ports in Lilongwe).

(3) Collaboration with the The JICA Technical Cooperation Project of NRW

Smooth implementation of procured equipment shall be conducted in order not to hinder the effects of the the JICA Technical Cooperation Project of NRW for NRW reduction, scheduled to be implemented in the future.

2-2-4-3 Scope of Works

The scope of implementation of the Project on the Japanese side and Malawian side is organized as follows.

Table 2-13 : Division of implementation of the Project on the Japanese side and Malawian side

Work Contents	Malawian side	Japanese side
1. Procurement of Equipment		○
2. Securing Storage Spaces for Procured Equipment	○	
3. Supplementary Work for Procured Equipment		
● Foundation and Wiring Work for a Back-up Generator	○	
4. Transportation and Customs Clearance of Equipment		
● Marine Transportation to Beira Port		○
● Customs Clearance	○	
● Tax Exemption such as Custom Duties and VAT	○	
● Acquisition of Import Permits for Equipment	○	
● Inland Transportation to LWB HQ and Mwenda Booster Pump Station		○
● Transportation from LWB HQ to each Zone Office	○	
5. Issue of Banking Arrangement and Authorization to Pay		
● Signing of Banking Arrangement (B/A)	○	
● Issue of Authorization to Pay (A/P)	○	
● Various Expenses Burden for Items listed above	○	
6. Permission/Procedures and Burden of Expenses necessary for Immigration and Stay in Malawi	○	
7. Permissions/Procedures necessary for the Project Implementation	○	
8. Burden of Costs on related work not included in the Scope of Grant Aid	○	
9. Consulting Service		
● Support for Preparation of Bidding Documents		○
● Service for Bid Opening and Supervision of Procurement		○
10. Inspection of Procured Equipment		
● Inspection of Procured Equipment		○
● Attendance for Inspection	○	

2-2-4-4 Consultant Supervision

(1) Basic Policy

The consultant shall supervise the operation of the procurement agent in order for the contract to be fulfilled properly and smoothly. The purposes of procurement supervision are as follows: (i) to supervise the proper implementation of procured equipment to ensure a predetermined quality, in accordance with the specifications defined in the contract and (ii) to confirm no differences between procured equipment and ones specified in the contract in terms of quality, standard and function. Moreover, the consultant also needs to supervise the proper organization and preservation of documents related to quality control data and photographs of procured equipment.

(2) Procurement Supervision Plan

The works for the consultant's procurement supervision are as follows:

◆ Verification of Equipment Design (Japan)

Confirm whether the procurement agency designs equipment compliant with the required specifications

◆ Equipment Inspection (Japan)

Confirm whether the equipment satisfies the required specifications in the manufacturing process

◆ Verification of Equipment before Shipping (Japan)

Confirm whether the equipment, in accordance with the required specifications and quantity, is loaded before the equipment is shipped from the international loading port near the manufacturing company.

◆ On-site Procurement Supervision (Recipient Country)

Confirm whether the equipment, in accordance with the required specifications and quantity, is loaded when they arrive at the destination and is installed properly. In addition, the consultant needs to supervise the initial operation guidance by the procurement agency.

◆ Inspection and Acceptance, and Handover (Recipient Country)

Conduct finalized confirmation whether the equipment is procured, in accordance with the required specifications and quantity, at the final destination of LWB headquarters or the Mwenda Booster Pump Station, with the presence of the executing agency (MAIWD or LWB). In addition, the consultant needs to hand over the equipment, which satisfies the requirement, to the other party and confirm the contents in writing. Regarding a back-up generator installed at the Mwenda Booster Pump Station, Japanese companies will connect the generator to the control panel (Automatic Transfer Switch), and the LWB connects from the control panel to the booster pump and commercial power supply. Operation of the generator in the test operation mode allows confirming the independent operation and thus, inspection, test operation and handover can be performed before the wiring work of the LWB.

◆ Confirmation of Final Installation

Confirm whether the equipment to be inspected and handed over at LWB headquarters (except for [501 Back-up Generator]) is transported to each Zone Office by LWB and installed at an appropriate location.

The consultant's procurement supervisory staff members are planned as follows:

Table 2-14 : Staff members for consultant's procurement supervise

Personnel	Work contents	Dispatch Period
Chief Consultant	Project Management, Inspection/Handover and Confirmation of Final Instllation etc.	Total 0.40 M/M
Procurement Supervisor	On-site Procurement Supervion	Total 0.77 M/M
Inspector	Product Inspection, Verification of Manufacture Drawing and Equipment before Shipping	Total 0.30 M/M

2-2-4-5 Quality Control Plan

Procured equipment for the Project shall be procured by Japanese agency selected by general competitive bidding. Verification of manufacture drawing and collation/product inspection shall be conducted in order to secure the quality of procured equipment.

Verification of manufacture drawing and collation inspection will be conducted for [112 Truck with Crane] or [119 Transporter Truck for Small Excavators]. Meanwhile, the following equipment will be examined at their factory of manufacture; [111 Small Excavator], [112 Truck with Crane], [119 Transporter Truck for Small Excavator], [201 Leak Detection Tools], [203 Water Pressure Meter], [204 Leak Sound Detection Bar], [205 Sound Water Pipe Locator] and [501 Back-up Generator]. The consultant will be assigned to receive the procured equipment, verify the required specifications and quantity and supervise the initial operation guidance by the procurement agency in order to ensure the quality.

2-2-4-6 Procurement Plan

(1) Procurement Method

Equipment for pipe installation; leak management; management and inspection; and back-up generator is presumed to be procured as equipment for NRW reduction. Leak management equipment will be procured from overseas countries including Japan because it is not distributed in Malawi. It will be also procured through the the JICA Technical Cooperation Project of NRW reduction. Thus, the affinity with the equipment procured through the Technical Cooperation Project of NRW needs to be considered, in addition to price comparison. Other equipment components are available in Malawi and therefore, locally procured items and Japanese procured items will basically be compared and examined for the Project. In particular, the compatibility with the existing pipe material standard, which is principally British or ISO Standards in Malawi, shall be examined for tools and pipe materials for pipe installation.

(2) Procurement Plan of Replacement and Consumable Goods

The Project will procure a year's worth of consumable goods for procured equipment.

(3) Transportation Plan

The procured equipment for the Project will be shipped to LWB headquarters in Lilongwe City under the burden of the Japanese side. Procurement of equipment in Japan is generally unloaded either at Durban Port in South Africa or Beira Port in Mozambique and transported to Lilongwe City by land. There are roads that can transport 40 foot containers from each port, and transport takes about 10 days from Durban Port to Lilongwe City and 5 days from Beira Port to Lilongwe City. Beira Port was refrained from being used owing to the public security issues in the past. However, after the ceasefire agreement between the Mozambique government and the armed group (Renamo party), the situation has improved. It has become common to use the transportation route via Beira Port these days due to the short number of days required. Transportation route via Beira Port is considered for the Project because there is a cost benefit. Regarding overseas procurement of equipment, it is basically transported by container (20 or 40 feet). Meanwhile, trucks with cranes and transporter trucks for small excavators will be transported by self-drive, and small excavators and a back-up generator will be transported by a flat container (offshore) and trailer (inland).

The equipment departed from Japan will go through the inspection at Beira port, where it is unloaded. The equipment will be transfered from a bonded area[5] in Beira Port to a bonded area in Malawi (a border between Malawi and Mozambique or a dry port in Lilongwe) by presenting a bill of lading (B/L) stating that it is cargo for Malawi. After the transportation, customs procedures including tax exemption are implemented in bonded areas of Malawi.

It takes about 40 days for martime transport, 7 days to undergo the inspection and transfer to cargos at Beira Port, 7 days to transport by land and 10 days to clear tax exemption and customs inspection procedures at bonded area in Malawi.

[5] Bonded transportation: transporting goods as foreign cargoes between bonded areas

Table 2-15 : Transportation method and route

Item	Required Periods
Marine Transport form Japan to Beira Port	40 days
Inspection and Transfer to cargos at Beira Port	7 days
Beira Port to Lilongwe City	7 days
Tax Exemption at Bonded Area in Malawi	10 days
Total	64 days

The final destination of the equipment by Japanese supplier shall be the LWB headquarters, and LWB respoisibly shall allocate them appropriately to Zone Offices after the inspection. However, the [501 Back-up Generator] installed at the Mwenda Booster Pump Station (within the site of the South Zone Office) is a large-scale and heavy item; Japanese engineers will concudt an unpacking work after procurement. Thus, Japanese supplier will transport the back-up generator to the Mwenda Booster Pump Station, and install and inspect the equipment.

(4) Installation Plan

Regarding [501 Back-up Generator], unpacking, delivery and arrangement work will be performed and it is expected to take 5 days. The foundation work of the installation location of [501 Back-up Generator] and the wiring work after unpacking are not budgeted because they are arranged as obligations for LWB. The period of temporary staffing for installation work is planned as follows.

Table 2-16 : Plan of temporary staffing for installation work

	Personnel	Equipment	No. of Travels	Required Periods			Place
				Transport	Work	Total	
1	Japanese Engineer	501 Back Up Generator	1 time	4 days	5 days	9 days	Lilongwe
2	Local Engineer	501 Back Up Generator			5 days	5 days	
Total			1 time	4 days	10 days	14 days	

(5) Adjustment and Trial Operation Plan

Adjustment and trial operation is planned for the Project concerning [111 Small Excavator] and [501 Back-up Generator]. It is expected to take 1 day for [111 Small Excavator] and 4 days for [501Back-up Generator]. The period of temporary staffing for adjustment and trial operation is planned as follows.

Table 2-17 : Plan of temporary staffing for adjustment and trial operation

	Personnel	Equipment	No. of Travels	Required Periods			Place
				Transport	Work	Total	
1	Japanese Engineer	111 Small Excavator	1 time	4 days	1 days	5 days	Lilongwe
2	Local Engineer	501 Back Up Generator	*	*	4 days	4 days	
Total			1 time	4 days	5 days	9 days	

* Not counted as his/her work will be continued to be conducted from the previous process.

2-2-4-7 Opetational Guidance Plan

Initial operation guidance is carried out at the time of delivery of equipment such as [101 Pipe Drilling Tools], [111 Small Excavator], [201 Leak Detection Tools], [203 Water Pressure Meter], [204 Leak Sound Detection Bar], [205 Sound Water Pipe Locator] and [501 Back-up Generator]. The period of temporary staffing for initial operation guidance is planned as follows.

Table 2-18 : Plan of temporary staffing for initial operation guidance

	Personnel	Equipment	No. of Travels	Required Periods			Place
				Transport	Work	Total	
1	Japanese Engineer	111 Small Excavator	*	*	2 days	2 days	Lilongwe
2	Japanese Engineer	101 Pipe Drilling Tools 201 Leak Detection Tool 203 Pressure Meter With Data Logger 204 Leak Sound Detection Bar 205 Pipeline Detector	1 time	4 days	4 days	8 days	
3	Japanese Engineer	501 Back Up Generator	*	*	3 days	3 days	
Total			1 time	4 days	9 days	13 days	

* Not counted as his/her work will be continued to be conducted from the previous process.

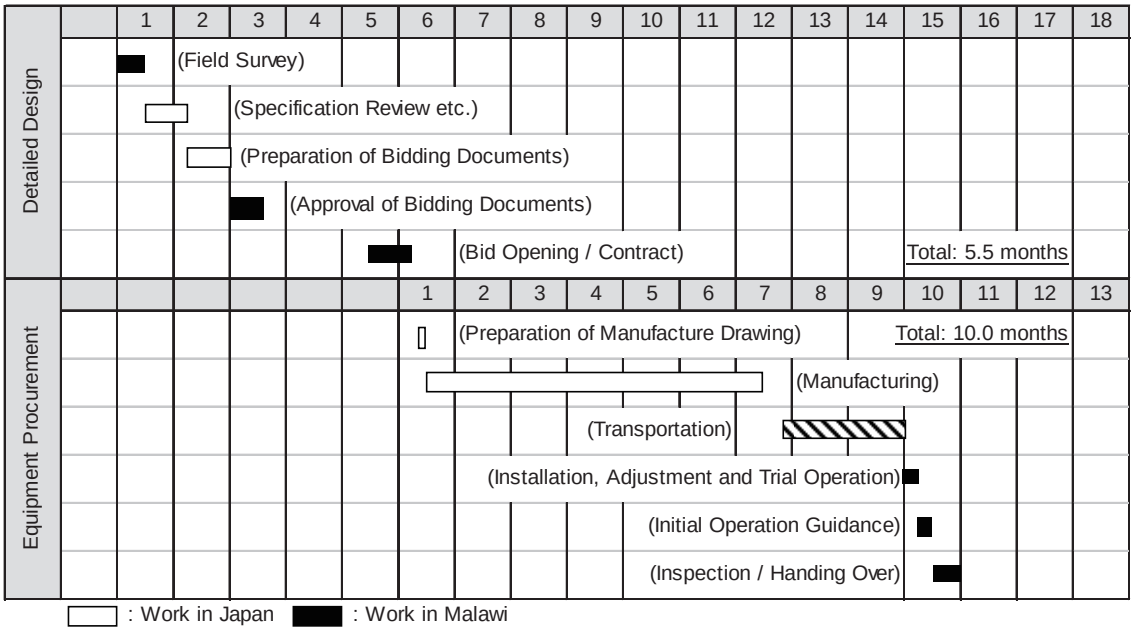
2-2-4-8 Soft Component Plan

Proposed procurement of equipment for the Project is utilized in the ordinary work at LWB except for leak detection tools and staff members understand its intended use and operation method. Although some procurement of equipment requires initial operation guidance, they are basically general-purpose equipment, which has a low degree of difficulty. Leak detection tools are not used in ordinary work, though initial operation guidance enables for LWB staff members to acquire its usage purpose and operation method. Therefore, technical support (soft component) will not be planned for the Project.

2-2-4-9 Implementation Schedule

The implementation schedule for the Project is as follows.

Table 2-19 : Implementation schedule for the Project



2-3 Obligations of Recipient Country

The obligations of MAIWD and LWB as executing agencies are as shown below. These obligations shall be implemented mainly by LWB; however, MAIWD shall provide a support for tax exemption.

Table 2-20 : The obligations of MAIWD and LWB as executing agencies

Obligation Items	Implementation Period*	Required Periods
Securing Storage Spaces for Procured Equipment	Before Arrival of Equipment (Until May 2019)	About 30 days
Supplementary Work for Procured Equipment		
● Foundation Work to Install a Back-Up Generator	Before Arrival of Equipment (Until May 2019)	About 30 days
● Wiring Work for a Back-Up Generator	After Arrival of Equipment (June 2019)	About 10 days
Transportation and Customs Clearance of Equipment		
● Customs Clearance	After B/L Issued (March 2019)	About 10 days
● Tax Exemption such as Custom Duties and VAT LWB prepare required documents and submit them to MRA through the principal secretary of MAIWD	After B/L Issued (March 2019)	About 30 days
● Acquisition of Import Permits for Equipment	After B/L Issued (March 2019)	About 30 days
● Transportation from LWB HQ to each Zone Office	Immedeately after Inspection of Equipment (After June 2019)	–
Issue of Banking Arrangement and Authorization to Pay		
● Signing of Banking Arrangement (B/A)	After E/N and G/A Singned (March 2018)	About 2 days
● Issue of Authorization to Pay (A/P)	After B/A Singned (March 2018)	About 2 days
● Various Expenses Burden for Items listed above	As appropriate (March 2018)	–
Permission/Procedures and Burden of Expenses necessary for Immigration and Stay in Malawi	As appropriate (After April 2018)	–
Permissions/Procedures necessary for the Project Implementation	As appropriate (After April 2018)	–
Burden of Costs on related work not included in the Scope of Grant Aid	As appropriate (After April 2018)	–
Attendance for Inspection	At the time of Inspection (June 2019)	About 8 days

* It is assumed that E/N and G/A will be concluded in March 2018.

2-4 Project Operation Plan

The procured equipment for the Project are devices to be utilized mainly for the daily work of Zone Office such as water pipe installaton; and management and inspection. LWB staff members have already acquired the basic knowledge on the utilization and operation of the equipment. As specialized knowledge is not necesary to operate and maintenance the equipment, it can be conducted without any difficulties under the current structure of LWB.

Neverheless, LWB shall operate equipment properly in order to implemente NRW reduction sustainably and effectively, and thus they need to learn operation and maintenance method through the initial guidance and use them sustainably and effectively to prevent breakage and breakdown in advance. As a maintenance method, the following are expected to be implemented: “Pre-operation Inspection” that confirms the appearance and operation of procured equipment; and “Periodic Inspection” that performs tightening bolts for equipment with a drive part, injection of oils, replacement of oil filters and washing air filters every half year. Precision inspection (precision calibration) is not assumed to be conducted because instruments such as leak detection and pressure meter with data logger do not need to calibrate accuracy.

Thus, maintenance can be carried out under the current structure of LWB because it only requires basic inspection and specialized knowledge is not necessary to operate and maintain the equipment.

Table 2-21 : Maintenance and management of procured equipment in LWB

Component	No.	Equipment	Pre-operation Inspection	Periodic Inspection	Responsible
Pipe Installation	101	Pipe Drilling Tools	○		North Central South Zone Offices
	103	Pipe Threading Tool	○		
	105	Pipe Cutter	○	○	
	106	Lifting Tools	○		
	107	Small Generator	○	○	
	108	Electric Welding Machine	○	○	
	109	Tools	○		
	110	Compactor	○	○	
	111	Small Excavator	○	○	
	112	Truck with Crane	○	○	
	113	Engine Pump	○	○	
	114	Lighting Gear	○	○	
	115	Pipe Repair Clamp and Dresser Joint			
	117	Water Pressure Test	○	○	
	119	Transporter Truck for Small Excava	○	○	
Leak Management	201	Leak Detection Tool	○		
	203	Pressure Meter With Data Logger	○		
	204	Leak Sound Detection Bar	○		
	205	Pipeline Detector	○		
Management and Inspection	301	Accuracy Tester of Water Meter	○		
	302	Pressure Gauge for Water Faucet	○		
	304	Motorcycle	○	○	
Back-up generator	501	Back Up Generator	○	○	South Zone Office

Source: The Survey Team

2-5 Project Cost Estimation

2-5-1 Initial Cost Estimation

(1) Expense Burden on Malawian Side

The burden expenses of LWB as the executing agency, out of the Project cost, are estimated as follows.

Table 2-22 : Malawian side burden expenses

Burden expenses on the Malawi side: 18 K USD

Burden Organization	Obligations		Cost USD
LWB	Issue of A/P	0.05% of the Project Cost Estimation	1,602.9
	Securing Storag Speca for Equipment	Additional Space of 20.54 m2	10,919.1
	Secureing Space for a Back-Up Generator	Foundation and Wiring Works	6,195.2
Total			18,717.2

Expenses for space expansion include the cost to secure the storage space for pipe repair clamps and dresser joints. Pipe materials are managed at a warehouse at LWB headquarters and the required quantities are distributed to the North, Central and South Zone Office accordingly. Thus, expenses for storage expansion are posted for LWB headquarters only. Regarding each Zone Office, equipment storage places (caretakers' offices or warehouses) and parking spaces are within the office and thus, it is not necessary to secure a new storage for procured equipment.

In addition, expense for foundation work (45 m^2) and wiring work are posted to install back-up generators at the Mwenda Booster Pump Station (the South Zone Office).

(2) Estimation Conditions

1) Reference Point of Estimation

The Survey of the Project ended on August 17, 2017. Therefore, the reference point of estimation is August 2017.

2) Foreign Exchange Rates

The exchange rate is as follows.

- ◆ USD/JPY: 1 USD = 112.83 JPY
- ◆ MWK/JPY: 1USD = 0.0139JPY

3) Procurement Period

The procurement period is shown in "2-2-4-9 Implementation Schedule".

4) Others

The approximate project cost was estimated in accordance with the conditions of the scheme of Japanese Grant Aid.

(3) Preliminary Expenses

The inflation rate of Malawi[6], according to the announcement by the International Monetary Fund (IMF), has exceeded 20% from 2012 to 2016, and it is predicted to be around 9 to 12% from 2017 to 2019. However, preliminary expenses may not need to be considered for the Project, as the proportion of local currency is small.

Furthermore, there is no possibility that the policy and direction of countermeasures against groundwater development for MAIWD and NRW reduction for LWB will be changed at the implementation stage of the Project and thus, there would be no risk of alternation in design contents.

2-5-2 Operation and Maintenance Cost

2-5-2-1 Specifications of Operation and Maintenance Cost

Arrangement of new personnel is not required to operate and maintain the equipment to be procured under the Project since the equipment will be utilized for daily and regular work (pipe repair work) mainly at LWB Zone Offices. Most of the equipment such as excavators, tools, hangers, water pressure gauge, etc., does not require operating costs (fuel cost). On the other hand, operating costs are required for the equipment such as small excavators, small power generator, trucks with cranes, transporter truck for small excavator, motor bikes and back-up generators. In addition, LWB has to prepare consumable goods, such as cutter blades, oil and air filters, for maintenance of the equipment except pipe repair clamps, joints and tools.

2-5-2-2 Operation and Maitenance Cost

Operation and maintenance expenses, including cost for personnel, fuel and consumable goods, are estimated as follows.

Table 2-23 : Operation and maintenance expenses in LWB

Unit: Million MWK

Item			Unit	Various Elements of Operation Cost *1			Cost *2
				Annual Max. Operation Time	Fuel Consumption (L/h)	Fuel Consupmption Amount (L)	
Personnel Expenses (2 Operators)			1 Unit				7.5
Operation cost	Fuel Cost		1 Unit				80.5
		Small Excavator	1 Unit	3,600.0	2.8	10,080	8.2
		Small Generator	1 Unit	2,400.0	1.2	2,880	2.4
		Truck with Crane	1 Unit	7,200.0	4.6	33,120	27.3
		Transporter Truck for Small Excavator	1 Unit	7,200.0	4.6	33,120	27.3
		Motorcycle	1 Unit	5,880.0	3.1	18,092	14.9
		Back Up Generator	1 Unit	3.4	110.0	372	0.3
	Cost for Consumables Goods *3		1 Unit				41.2
	Total Opeation Cost						121.6
Total							129.1

*1 Fuel consumption is refered to "Loss statement for construction machinery in FY2008".

*2 Personnel expenses are calculated by the annual salary of 2 operators of "Small Excavator ".
Fuel cost is caluculated 824.7 MWK/L for petrol, 815.8 MWK/L for diesel.

*3 The same amount of cost for consumables goods is allocated for the Cost Estimation for the Project.

[6] Inflation rate: World Economic Outlook Database, April 2017

Regarding operation and maintenance expenses after completion of the Project, the personnel expenses are estimated to be 7.5 million MWK per year (about 1.2 million yen), and the operation cost is estimated at 121.6 million MWK per year (about 19.0 million yen). The personnel expenses are approximately 0.3% against the personnel expenses (2,725 million MWK) of the LWB budget in FY 2017/18 and the operation expenses accounted for roughly 2.1% of operating cost (5,886 million MWK) respectively. Based on the present situation that the budget is continuously increasing from the previous fiscal year and current situation that the surplus in the profit and loss account continues since FY2013/14, the allocation of operation and maintenance expenses under the current budgetary measures is sufficient. Net income for FY2015/16 is 2,753 million MWK (approximately 432 million JPY), which is a sufficient financial condition to appropriate operation and maintenance expenses. Therefore, it is considered that the future operation and maintenance costs can be sufficiently allocated by the current budgetary measures.

Chapter 3 Project Evaluation

Chapter 3 Project Evaluation

3-1 Preconditions

For the smooth implementation of the Project, the prerequisites to be taken by the Malawian side have been arranged as shown in Table 3-1.

These prerequisites need to be surely implemented, at an appropriate time, by the Malawian side.

Table 3-1 : Prerequisites for implementing the Project

Obligation Items	Implementation Period
Securing Storage Spaces for Procured Equipment	Before Arrival of Equipment
Supplementary Work for Procured Equipment	
● Foundation Work to Install a Back-Up Generator	Before Arrival of Equipment
● Wiring Work for a Back-Up Generator	Before Arrival of Equipment
Transportation and Customs Clearance of Equipment	
● Customs Clearance	After B/L Issued
● Tax Exemption such as Custom Duties and VAT	After B/L Issued
● Acquisition of Import Permits for Equipment	After B/L Issued
● Transportation from LWB HQ to each Zone Office	After equipment arrival
Issue of Banking Arrangement and Authorization to Pay	
● Signing of Banking Arrangement (B/A)	After E/N and G/A Singned
● Issue of Authorization to Pay (A/P)	After B/A Singned
● Various Expenses Burden for Items listed above	As appropriate
Permission/Procedures and Burden of Expenses necessary for Immigration and Stay in Malawi	As appropriate
Permissions/Procedures necessary for the Project Implementation	As appropriate
Burden of Costs on related work not included in the Scope of Grant Aid	As appropriate
Attendance for Inspection	At the time of Inspection

3-2 Necessary Inputs by Recipient Country

(1) Maintenance for Sustainable Use of Equipment

NRW reduction plays an important role in improving the water supply situation in Lilongwe City. Sustainained implementation of pipe repairs and leak detection by LWB work team would be significant as a direct activity towards achieving NRW reduction. Sustainable use of procured equipment allows greatly improved work quality and efficiency of repairing pipes; and it enables to detect water leakage, which LWB was incapable of executing owing to lack of appropriate equipment. Thus, LWB shall maintain the procurement equipment sustainably to maintain a state where the procurement equipment can be used permanently.

(2) Cooperation with JICA Technical Cooperation Project

The Project procures the equipment leakage detection and rehabilitation, which will be newly implemented, in

addition to the equipment for pipe repairs as daily work (expansion of hard aspects). On the other hand, JICA Technical Cooperation Project, scheduled to be implemented in the future, aims to improve the experience and knowledge of on-site work such as repairing pipes and detecting water leakage, and to strengthen LWB's ability to reduce NRW (expansion of soft aspects). Active use of procured equipment for the Project through JICA Technical Cooperation Project of NRW is very effective in strengthening the ability of LWB to reduce NRW, and a synergistic impact is expected to achieve these projects' targets.

3-3 Important Assumption

The external conditions for the implementation of the Project are as follows.

- ◆ There is no change in the policy concerning improvement of water supply system in Malawi.
- ◆ There is no change in the policy concerning activities for NRW reduction in LWB

3-4 Project Evaluation

3-4-1 Relevance

"National Water Resource Master Plan" established through "Project for National Water Resources Master Plan Resources in the Republic of Malawi" (2012-2014) specifies an improvement of water supply in Lilongwe city as the top-priority. In particular, NRW reduction is referred to as the highest priority activity to improve water use efficiency of existing water resources. Moreover, LWB has set the goal to reduce NRW rate (36%) in 2015 to 28% in 2020 in the Strategic Plan. Hence, the Project is in accordance with these development plans in Malawi.

Additionally, "Country Assistance Policy for the Republic of Malawi" (April 2012) stated by the GoJ addresses "Improvement of basic social services" as priority areas and "Safe and Stable Water Supply Programme" is operated to tackle the priority area, and it aims to improve stable water supply through rehabilitation of facilities and enhancement of maintenance system. On that account, the Project corresponds to development cooperation policy of the GoJ to Malawi.

Indeed, LWB is the direct beneficiary of the Project; however citizens in Lilongwe including poor group will also be benefited by the Project since universal and equal access to safe and affordable drinking water to them will be realized thorough improvement of NRW management efficiency, reduction of NRW and improvement of the water supply service in Lilongwe.

Therefore, implementation of the Project is in line with Japanese cooperation policies and rolling plan as well as development plans and policies in Malawi. Maintenance of procured equipment for NRW reduction will lead to improvement of water use efficiency and water supply service, and it promotes Sustainable Development Goals 6 ("Ensure availability and sustainable management of water and sanitation for all ").

For these reasons, it is highly relevant to support the implementation of the Project.

3-4-2 Effectiveness

(1) Quantitative Impact

Utilization of equipment procured by the Project improves the work quality of pipe repairs and will lead to the reduction of working hours. Thus, it allows LWB to undertake leak detection, which was incapable of

executing owing to lack of suitable equipment. Quantitative impact indicators are set as shown in Table 3-2 to confirm the level of achievement of the Project impact.

Table 3-2 : Quantitative impact indicators

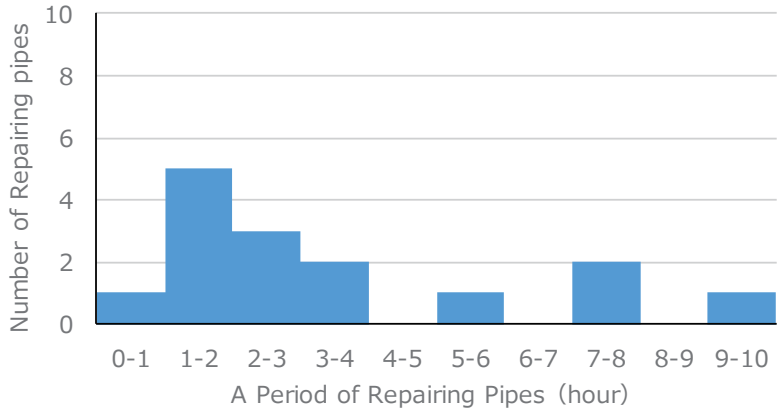
Indicator			Reference Value (2017)	Target Value in 2022 (3 years after installation)
NRW Reduction	A Period of Repairing Pipes	(hour/place)	2.5	1.5
	Leakage Detection Distance	(km/year)	0	175

Quantitative impact indicator is calculated based on previous work contents of LWB. External conditions are considered not to have an impact on the calculation since additional operation expenses due to the activity for NRW reduction, which is mainly fuel cost for machinery, is minor. Each indicator was set as follows.

1) A Period of Repairing Pipes (hours/place)

Reference Value

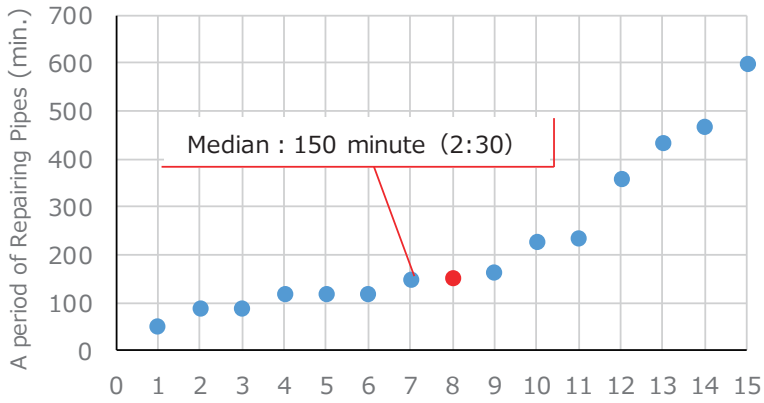
15 effective samples (data obtained from 10th September to 8th October, 2017) are extracted and arranged into histograms to understand the current state of period for repairing pipes, which is the time required to complete a pipe repair after receiving a complaint from either LWB headquarters or users. These samples are obtained from work management ledger at LWB North Zone Office.



Source : LWB data

Figure 3-1 : A period of Pipe repairs at LWB North Zone Office

A period of repairing pipes varies greatly according to the geographical conditions of the target places and external conditions such as pipe types, pipe diameters, and traffic congestion. Thus, it is effective to use a representative value, such as mean or median value, showing a statistical tendency when setting the quantitative impact indicator. The period of 1 to 2 hours have occurred most frequently, while the period of 0 to 1 hour and 9 to 10 hours have also occurred among these 15 samples. Hence, it is considered appropriate to set the medium value of 2.5 (hours/place) as a reference value of the quantitative impact indicator because it is not relatively affected by outliers (extreme values) and dispersion.



Source : The Survey Team

Figure 3-2 : Median values among effective samples

Target Value

Capacity and quantity of existing equipment, owned by LWB, are not sufficient due to depletion and aging. Thus, pipe repairs are mainly conducted with manpower or hand-powered and the efficiency and quality of works are not favorable. Pipe repairs are expected to be efficient and the required time is shortened greatly through the utilization of materials for pipe repair and replacement as well as engineering machinery such as small excavators or compactors to be procured for the Project.

As described above, the current period of pipe repairs is regarded as 2.5 hours/place (the reference value). Use of procurement equipment is assumed to shorten working hours and reduce the time up to 1.5 hours/place.

Table 3-3 : Shortening degree of a period for pipe repairs at each process

Unit : minute/place

Work Process	Current Status (Median Value of LWB Data)	After Procurement
1 Separate the Damaged Part after Leakage Reported	10	10
2 Excavation	60	30
3 Confirm the Situation	10	10
4 Repair Leakage	40	20
5 Backfilling (Recovering)	30	20
Total	150 (2.5 hours)	90 (1.5 hours)

Source : The Survey Team

Measuring the Level of Achievement of Project Impact

Under the present situation, work team have recorded the dates, places, contents, number of workers for pipe repairs and they are organized at each Zone Office. These recorded contents are varied because the recording format is not fixed among LWB staff members and the importance of referring to the past example is not recognized. The Survey Team presented a draft revision of the record format to LWB staff members and explained the importance of recording, organizing, making use of contents of the activities.

LWB headquarters and Zone Offices including the CEO understand and recognize the importance. The

Survey Team confirmed staff members at North Zone Office started recording the status of the required time and summary of each work process from receiving reporting to the completion of pipe repairs, starting from October 2017 and they are properly recorded. When implementing new initiatives at LWB, it is usual for North Zone Office to start a trial practice, where the staff is particularly ambitious and active, and later the activity can be deployed to other Zone Offices. Therefore, an awareness of importance in recording activities will be fostered in each Zone Office and a record system is expected to be constructed by June 2019, when the equipment of the Project are to be procured, through the dissemination of recording activities by North Zone Office. Therefore, the level of achievement of the Project impact is presumably confirmed through an inspection (monitoring) of work activities in forms of a weekly report and monthly report, which will be recorded by work team and organized by Zone Offices.

2) Leakage Detection Distance (km/year)

Reference value

At present, LWB does not carry out leakage detection and thus reference values (performance records of 2017) do not exist.

Target Value

As mentioned above, utilization of procured equipment will decrease a period of pipe repairs of 7,200 hours {= (2.5 hours/place - 1.5 hours/place) × 50 places/week × 4 weeks/month × 12 months/year × 3 Zone Offices} and it allows for LWB to apply the reduced time to leak detection and repairs. The average working hours excluding the time for transportation and preparation is about 6 hours/day and the time for leak detection and repairs is estimated as 1,200 days (= 7,200 hours/year ÷ 6 times/day). Thus, each Zone Office is able to apply 400 days (= 1,200 days ÷ 3 Zone Offices) to leakage detection and repairs annually. Assuming that a considerable number of underground leakages will be detected that could not be detected before, the amount of work for leak detection is considered as almost the same as that for leakage repair after detection. Therefore, the amount of leak detection and repair after detection is considered as 200 days/year respectively during the 400 days/year.

A progress on leak detection is considered as over 50 m of pipes per hour, considering that not only miscellaneous works occur such as removal works of underground objects but also it will be detected using tools of analog and digital type together. Assuming that the working hours of work team is 6 hours/day, it is possible to detect leakage over 300 m of pipes per day. Thus, practice of leakage detection is estimated as over 180 km of pipes per year (= 300 m/day × 200 days/year × 3 Zone Offices). The target route for leakage detection is about 1,750 km, consists of the entire pipe network, which means patrolling along all target route is estimated to take approximately 10 years. (= 1,750 km ÷ 180 km/year) Hence, the target value of the entire LWB Zone Office is set as 175 km (= 1,750 km ÷ 10 years) annually with an aim to complete the patrolling along all the routes in 10 years.

Measuring the Level of Achievement of Project Impact

Current status of LWB's recording activity is not well structured. However, as mentioned above, staff members at the North Zone Office started to record the status of the required time and outline for each activity since October 2017, and the result of activities is expected to disseminate to other Zone Offices. In addition,

staff members of the entire LWB Offices recognize the importance of recording activities of NRW reduction.

Especially leakage detection has never been conducted by LWB and it is critical to keep a record of activities. The recording of activity is scheduled to be commenced after June 2019 when the equipment is procured. Therefore, the level of achievement of the Project impact will be presumably identified through an inspection (monitoring) of work activities in forms of a weekly and monthly report, which will be recorded by work team and organized by Zone Offices.

(2) Qualitative Impact

The expected qualitative impact by implementing the Project are as follows.

- ◆ Improvement of LWB's management (by reduction of overtime through improving work efficiency and by increase of revenue due to increased revenue earning water)
- ◆ Improvement of satisfaction of LWB's customer (by improvement of reliability of LWB's work such as prompt pipe repairs)
- ◆ Water resource conservation in Lilongwe River basin (by reduction of excessive water intake from Lilongwe River due to leakage reduction)

The above has led to the conclusion that an implementation of the Project is highly relevant and effective.

〔Appendices〕

1. Member List of the Study Team

2. Study Schedule

3. List of Parties Concerned in the Recipient Country

4. Minutes of Discussions

5. Other Relevant Data

1. Member List of the Study Team

(1) The First Visit for Preparation Survey（15th July 2017 to 13th August 2017）

Name	Position	Organization
Mr. Akihiro MIYAZAKI	Team Leader	Japan International Cooperation Agency
Mr. Toshio MURAKAMI	Groundwater Development	Japan International Cooperation Agency
Mr. Koji SHIMIZU	Cooperation Planning	Japan International Cooperation Agency
Mr. Takeshi NAKANO	Chief Consultant/Water Supply Plan	Kokusai Kogyo Co., LTD.
Mr. Hiroshi TAKASHIMA	Sub Chief Consultant/NRW Management/Equipment Planning1	Kokusai Kogyo Co., LTD.
Mr. Masatoshi TANAKA	Groundwater Development/Equipment Planning 2	Kokusai Kogyo Co., LTD.
Mr. Kentaro SEYA	Maintenance and Management	Kokusai Kogyo Co., LTD.
Mr. Tetsuya SUZUKI	Procurement Planning 1/Cost Estimation	Kokusai Kogyo Co., LTD.
Ms. Ayaka TAMAI	Project Coordinator/Procurement Planning 2	Kokusai Kogyo Co., LTD.
Ms. Mariko TODA	GIS	Kokusai Kogyo Co., LTD.

(2) The Second Visit for Explaining Outline Design Plan（25th November 2017 to 8th December 2017）

Name	Position	Organization
Mr. Sadanobu SAWARA	Team Leader	Japan International Cooperation Agency
Mr. Tomohiro ARIMA	Cooperation Planning	Japan International Cooperation Agency
Mr. Takeshi NAKANO	Chief Consultant/Water Supply Plan	Kokusai Kogyo Co., LTD.
Mr. Hiroshi TAKASHIMA	Sub Chief Consultant/NRW Management/Equipment Planning 1	Kokusai Kogyo Co., LTD.

2. Study Schedule

Date			JICA	Chief Consultant/ Water supply plan	NRW management/ Equipment plan1	Development underground water/Equipment plan 2	Maintenance and Management	Procurement plan 1/Cost estimation	Coordinator/ Procurement plan 2	GIS
				Mr. Nakano	Mr. Takashima	Mr. Tanaka	Mr. Seya	Mr. Suzuki	Ms. Tamai	Ms. Toda
1	2017/7/15	Sat	Depart (Japan→)	Depart (Japan→)						
2	2017/7/16	Sun	Arrival (→Malawi)	Arrival (→Malawi)						
3	2017/7/17	Mon	Discussion of I/C	Discussion of I/C						
4	2017/7/18	Tue	Visit to Private Company	Visit to Private Company						
5	2017/7/19	Wed	Site survey	Survey for situation of other donors		Visit to Private company	LWB organization survey	Procurement survey	Visit to Private company	
6	2017/7/20	Thu	Signe on Minutes	Signe on Minutes		MAIWD Collect data	LWB survey		MAIWD Collect data	
7	2017/7/21	Fri	Depart (Malawi→)	MAIWD Donor survey	LWB donor survey	MAIWD Donor survey	LWB donor survey	Procurement survey	MAIWD Donor survey	
8	2017/7/22	Sat		Arrangement of documents･internal meeting						
9	2017/7/23	Sun		Arrangement of documents						
10	2017/7/24	Mon		MAIWD Collect data	LWB site survey	MAIWD Collect data	LWB site survey	Procurement survey	MAIWD Collect data	
11	2017/7/25	Tue		MAIWD organization survey	LWB site survey	MAIWD organization survey	LWB site survey	Procurement survey	MAIWD organization survey	
12	2017/7/26	Wed		MAIWD O&M survey	LWB site survey	MAIWD O&M survey	LWB site survey	Procurement survey	MAIWD O&M survey	
13	2017/7/27	Thu		MAIWD organization survey	LWB site survey	MAIWD organization survey	LWB site survey	Procurement survey	Tax survey	
14	2017/7/28	Fri		MAIWD Collect data	LWB site survey	MAIWD Collect data	LWB site survey	Procurement survey	Tax survey	
15	2017/7/29	Sat		Arrangement of documents･internal meeting						Depart (Japan→)
16	2017/7/30	Sun		Arrangement of documents						Arrival (→Malawi)
17	2017/7/31	Mon		Arrangement of documents	LWB site survey	Arrangement of documents	LWB site survey	Procurement survey	Arrangement of documents	GIS survey
18	2017/8/1	Tue		MAIWD O&M survey	LWB O&M survey	MAIWD O&M survey	LWB O&M survey	Collect quotation	MAIWD O&M survey	GIS survey
19	2017/8/2	Wed		MAIWD budget survey	LWB O&M survey	Arrangement of documents	LWB O&M survey	Collect quotation	MAIWD budget survey	GIS survey
20	2017/8/3	Thu		Tax survey	LWB budget survey	MAIWD equipment survey	LWB budget survey	Collect quotation	Tax survey	LWB custom fee survey
21	2017/8/4	Fri		MAIWD equipment survey	LWB store survey	MAIWD equipment survey	LWB store survey	Collect quotation	MAIWD equipment survey	GIS survey
22	2017/8/5	Sat		Arrangement of documents･internal meeting						
23	2017/8/6	Sun		Arrangement of documents						
24	2017/8/7	Mon		Simple water supply plan		Arrangement of documents	LWB O&M survey	Collect quotation	MAIWD O&M survey	LWB custom fee survey
25	2017/8/8	Tue		Simple water supply plan			LWB O&M survey	Collect quotation	Technical notes	GIS survey
26	2017/8/9	Wed		Technical notes			LWB O&M survey	Collect quotation	Technical notes	Arrangement of documents
27	2017/8/10	Thu		Signing on Technical notes/JICA Malawi office				Collect quotation	Signing on Technical notes/JICA Malawi office	
28	2017/8/11	Fri		Depart (Malawi→)						
29	2017/8/12	Sat		Depart (Trangit)						
30	2017/8/13	Sun		Arrival (→Japan)						

※ MAIWD : Ministry of Agriculture, Irrigation and Water Development、LWB : Lilongwe water Board

Date			Team Leader	Corporation planning	Chief Consultant/ Water supply plan	NRW management/ Equipment plan1
			Mr. Sawara	Mr. Arima	Mr. Nakano	Mr. Takashima
1	2017/11/25	Sat			Depart (Japan→)	
2	2017/11/26	Sun		Depart (Japan→)	Arrival (→Malawi)	
3	2017/11/27	Mon		Arrival (→Malawi)	Meeting and Discussion with JICA, MAIWD, LWB	
4	2017/11/28	Tue		Site visit	Meeting MAIWD and LWB	
5	2017/11/29	Wed		Site visit	Meeting MAIWD and LWB	
6	2017/11/30	Thu		Site visit	Meeting MAIWD and LWB	
7	2017/12/1	Fri		Site visit	Meeting MAIWD and LWB	
8	2017/12/2	Sat		Site visit	Arrangement of Documents	
9	2017/12/3	Sun		Internal meeting	Internal meeting	
10	2017/12/4	Mon	Depart (Japan→)	Meeting MAIWD and LWB		
11	2017/12/5	Tue	Arrival (→Malawi)	Meeting MAIWD and LWB		
12	2017/12/6	Wed	Meeting for M/D			
13	2017/12/7	Thu	Singing on M/D, Depart (Malawi→)			
14	2017/12/8	Fri	Arrival (→Japan)			

※ MAIWD : Ministry of Agriculture, Irrigation and Water Development、LWB : Lilongwe water Board

3. List of Parties Concerned in the Recipient Country

Name	Position
MAIWD	
Mr. Brian MPHANJE	Assistant/Department of Water Resources
Ms. Christine MAWANGA	Department of Human Resource
Mr. Collings CHIVUNGA	Former Officer (Retirement)/Department of Resources
Mr. Dennis SITI	Accountant/Department of Finance
Mr. Ganizani MATIKI	Principle Hydrogeologist/Department of Water Resources
Mr. George CHANDE	Deputy Director/Department of Planning
Mr. Humphrey SAPULAYI	Senior Mechanical Engineers/Department of Water Resources
Mr. Kamuga MSONDA	Principle Hydrogeologist/Department of Water Resources
Mr. Macpherson NKHATA	Chief Hydrogical Resarch Officer/Department of Water Resources
Mr. Madaritso MAKONO	Mechanics/Department of Water Resources
Ms. Modesta KANJAYE	Director/Department of Water Resources
Mr. Nelson MZUMARA	Senior Economist/Department of Planning
Mr. Peter CHIPETA	Regional Irrigation & Water Development Officer/ Central Regional Water Development Office
Mr. Prince MLETA	Deputy Director/Department of Water Resources
Mr. Ron CHWAULA	Senior Drilling Officer/Department of Water Resources
Ms. Zione UKA	Chief Geological Development Officer/Department of Water Resources
LWB	
Mr. Alfonso CHIKUNI	Chief Executive Officer
Mr. Amos MLONGOLA	Network Tech. Engineer
Ms. Anges MBALE	M&E Office
Mr. Bester KAMWAZA	Operations Support
Mr. Damiano CHIMBAYO	Motor Vehicle Workshop
Mr. Dan MACHISA	Store Section/Clerk
Mr. Daniel MACHISA	Procurement Assistant
Mr. Devlin CHIRWA	Zone Manager S
Mr. Emmanuel SUMBWI	Geographic Information System Officer
Mr. Ephraim BANDA	Technical Services/Acting Projects Implementation Unit Manager
Ms. Esther PHIRI	Ass. Projects Engineer
Mr. F.H. KAMNHWANI	Zone Manager C
Mr. Fred CHILAMBA	Store Supervisor
Mr. Gift BANDA	Management Accountant
Mr. Gustaff CHIKASEMA	Corporate Planning Manager
Mr. Maclean Guy NYANG'WA	Director of Technical Services
Mr. McLennan NYANG'WA	Administration/Director of Technical Services
Mr. Rodney MTONDA	Elect/Mech Support
Mr. Ronald GUNDAMTENGO	Projects Engineer
Mr. Silli MBEHE	Director of Finance
Mr. Stevie KAZEMBE	Acting Procurement Specialist
Mr. Trevor H PHOYA	Administrative Officer/Administration Division
Mr. Valentine KAUPA	Acting Zone Manager (North)
Malawi Revenue Authority	
Mr. Martin KASAILA	Taxpayer Service Team Leader
Mr. Oscar M. MATEWARA	Deputy Station Manager-Enforcement

Name	Position
World Bank	
Mr. Josses MUGABI	Sr Water & Sanitation Sepc.

Name	Position
UNICEF	
Mr. Patrick A. OKUNI	WASH Specialist
Ms. Tabithah D. MKANDAWIR	Water Sanitation & Hygiene Officer
Private Company	
Mr. Enock ZIMBA	Tropical Drilling Company（Managing Director）
Mr. Navin HIRAWI	Chitsime Drilling Company（Operation Manager）
Mr. Rem ELIAS	Watertech Drilling Contractors（Managing Director）
Mr. Rob BECKERS	Vitens Evides International（Resident Project Manager Malawi）
Mr. Theo JANSSEN	Vitens Evides International（NRW Expert）
JICA Malawi office	
Mr. Koichi KITO	Chief Representive
Mr. Yoshikazu WADA	Deputy Resident Representative
Mr. Shinpei AKATSUKA	Assistant Resident Representative
Mr. Takeshi HIGO	Water Resource Adviser
Mr. Kapalamula GODFREY	Chief Programme Officer
Ms. Tamanda KALEKE	Programme Officer

4. Minutes of Discussions

Minutes of Discussions on 20th July 2017

Technical Notes on 10th August 2017

Minutes of Discussions on 6th December 2017

Minutes of Discussions on 20th July 2017

MINUTES OF DISCUSSIONS
ON
THE PREPARATORY SURVEY
ON
THE PROJECT FOR IMPROVEMENT OF GROUNDWATER DEVELOPMENT AND NON-REVENUE WATER REDUCTION

Based on the several preliminary discussions between the Government of the Republic of Malawi (hereinafter referred to as "Malawi") and Japan International Cooperation Agency (hereinafter referred to as "JICA") Malawi Office, JICA dispatched the Preparatory Survey Team for the Outline Design (hereinafter referred to as "the Team") of the Project for Improvement of Groundwater Development and Non-Revenue Water Reduction (hereinafter referred to as "the Project") to Malawi, headed by Akihiro MIYAZAKI, Director of Water Resources Team 2, JICA, from July 17 to Aug 11, 2017.

The Team held a series of discussions with the officials of the Government of Malawi and conducted a field survey. In the course of the discussions, both sides have confirmed the main items described in the attached sheets.

Lilongwe, July 20, 2017

Mr. Akihiro MIYAZAKI
Leader
Preparatory Survey Team
Japan International Cooperation Agency
Japan

Mrs. Modesta B. Kanjaye
Director
Department of Water Resources
Ministry of Agriculture, Irrigation and Water Development
Malawi

Mr. Alfonso Chikuni
Chief Executive Officer
Lilongwe Water Board
Malawi

ATTACHMENT

1. Objective of the Project

The objective of the Project is to enhance implementing capacity for increasing drinking water in rural areas and improving water use efficiency in the capital city in Malawi by procuring and installing equipment for groundwater development and non-revenue reduction, thereby contributing to improve water supply in Malawi.

2. Title of the Preparatory Survey

Both sides confirmed the title of the Preparatory Survey as "the Preparatory Survey for the Project for Improvement of Groundwater Development and Non-Revenue Water Reduction".

3. Project site

Both sides confirmed that the sites of the Project are Entire Malawi for Groundwater Development and Lilongwe City for Non-Revenue Water Reduction, which is shown in Annex 1.

4. Responsible authority for the Project

Both sides confirmed the authorities responsible for the Project are as follows:

4-1. Ministry of Agriculture, Irrigation and Water Development (hereinafter referred to as "the MAIWD") will be the executing agency for groundwater development of the Project (hereinafter referred to as "the Executing Agency"), and Lilongwe Water Board (hereinafter referred to as "the LWB") will be the executing agency for non-revenue water reduction of the Project. The Executing Agency shall coordinate with all the relevant authorities to ensure smooth implementation of the Project and ensure that the undertakings for the Project shall be managed by relevant authorities properly and on time. The organization chart of the Executing Agency is shown in Annex 2, and implementation structure of the Project are shown in Annex 6.

4-2. MAIWD shall be responsible for contracting with Japanese side, representing the executing agencies.

4-3. The above authorities responsible and implementation structure of the Project is tentative and subject to change when the scope of the project is changed.

5. Items requested by the Government of Malawi

5-1. As a result of discussions, both sides confirmed that the items requested by the Government of Malawi are as follows:

(1) Groundwater Development

- One drilling rig mounted on 4 by 4 truck for groundwater development (100m or deeper) to drill different size diameter holes equipped with DTH and Mud drilling facilities. Consideration should be made on maximum tonnage of the drilling machine to suit poor road network in rural areas
- One air Compressor mounted on 4by 4 truck
- 4 by 4 support truck lorry with crane
- Drilling hammers and bits of appropriate sizes
- Enough temporally steel casings to deal with unconsolidated formation deeper than 60 meters in order to be able to drill 100m or deeper boreholes
- Mobile workshop with necessary accessories
- Pumping test unit with high lift pump and bigger head and more riser to match the deeper wells
- GPS units
- Logging equipment, water level meters, borehole depth meters and borehole cameras with long cables
- Geophysical Survey prospecting equipment with long cables
- Assorted drilling tools and fast wearing spare parts
- Plus associated training in operation and maintenance of the new equipment

(2) Non-Revenue Water Reduction

- Leakage detection equipment
- Pipe installing equipment
- Management and Inspection Equipment
- Dredging Machine

5-2. JICA will assess the feasibility of the above requested items through the survey, and low sustainable items will be removed from the Project scope. Preconditions for scoping the Project are as follows:

(1) Groundwater Development

1) MAIWD has a concrete plan for groundwater development with 100m or deeper, including some names and number of targeted villages/localities.
2) An Aquifer(s) has been identified by an existing hydrogeological survey.
3) MAIWD has sustainable operation and maintenance system for the

targeted drilling rig, such as stable supply chain of spare parts, skilled staffs, and financial resources.

4) The targeted villages or communities can operate and maintain developed wells with stable supply chain of spare parts, skilled mechanic, and sufficient financial resources.
5) Private companies do not have appropriate sustainable capacity for drilling 100m or deeper in Malawi.

(2) Non-Revenue Water Reduction

1) To be identified as prioritized equipment in the survey.
2) To contribute rolling out the output of the Project for Strengthening the Capacity of Non-Revenue Water Reduction for Lilongwe Water Board.
3) To ensure immediate use in the field.
4) No similar project / duplication with other development partners and proper sequencing of projects to be followed.

5-3. JICA will report the results of assessing the feasibility of the requested items to the Government of Japan. The final scope of the Project will be decided by the Government of Japan.

5-4. The Government of Malawi shall submit an official request to the Government of Japan through a diplomatic channel before September, 2017.

6. Procedures and Basic Principles of Japanese Grant

6-1. The Malawian side agreed that the procedures and basic principles of Japanese Grant as described in Annex 3 shall be applied to the Project.
As for the monitoring of the implementation of the Project, JICA requires Malawian side to submit the Project Monitoring Report, the form of which is attached as Annex 4.

6-2. The Malawian side agreed to take the necessary measures, as described in Annex 5, for smooth implementation of the Project. The contents of the Annex 5 will be elaborated and refined during the Preparatory Survey and be agreed in the mission dispatched for explanation of the Draft Preparatory Survey Report.
The contents of Annex 5 will be updated as the Preparatory Survey progresses, and eventually, will be used as an attachment to the Grant Agreement.

7. Schedule of the Survey

7-1. The Team will proceed with further survey in Malawi until Aug 11.

7-2. An official request to the Government of Japan will be submitted before

September, 2017.

7-3. JICA will prepare a draft Preparatory Survey Report in English and dispatch a mission to Malawi in order to explain its contents around late in November, 2017.

7-4. If the contents of the draft Preparatory Survey Report is accepted and the undertakings for the Project are fully agreed by the Malawian side, JICA will finalize the Preparatory Survey Report and send it to Malawi around March, 2018.

7-5. The above schedule is tentative and subject to change.

8. Environmental and Social Considerations

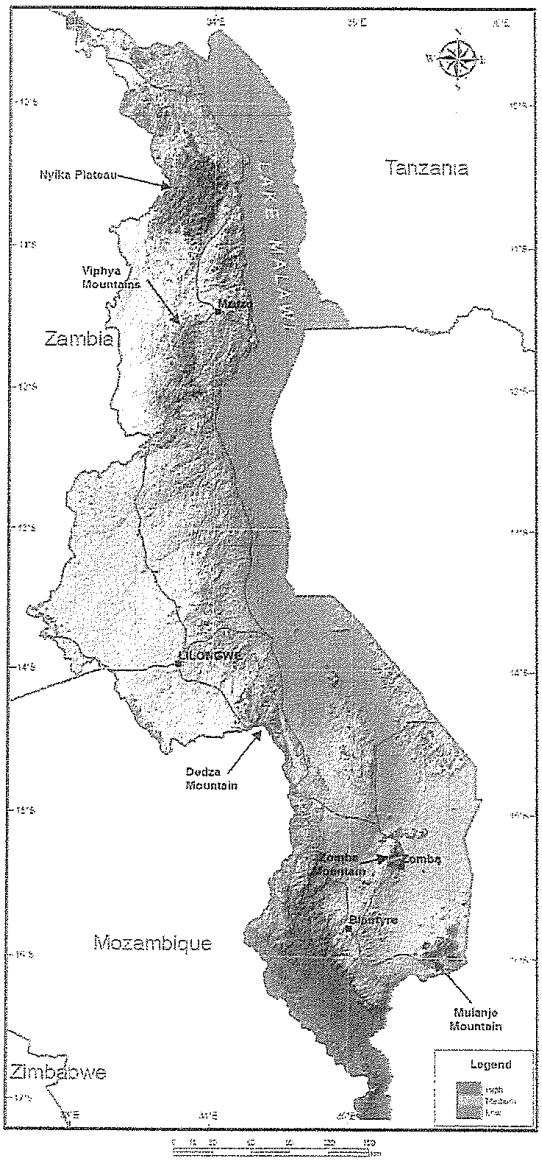
8-1. The Malawian side confirmed to give due environmental and social considerations before and during implementation, and after completion of the Project, in accordance with the JICA Guidelines for Environmental and Social Considerations (April, 2010).

8-2. The Project is categorized as "C" from the following considerations:
Not located in a sensitive area, nor has it sensitive characteristics, nor falls it into sensitive sectors under the Guidelines, and its potential adverse impacts on the environment are not likely to be significant.

Annex 1 Project Site
Annex 2 Organization Chart
Annex 3 Japanese Grant
Annex 4 Project Monitoring Report (template)
Annex 5 Major Undertakings to be taken by the Government of Malawi
Annex 6 Implementation Structure

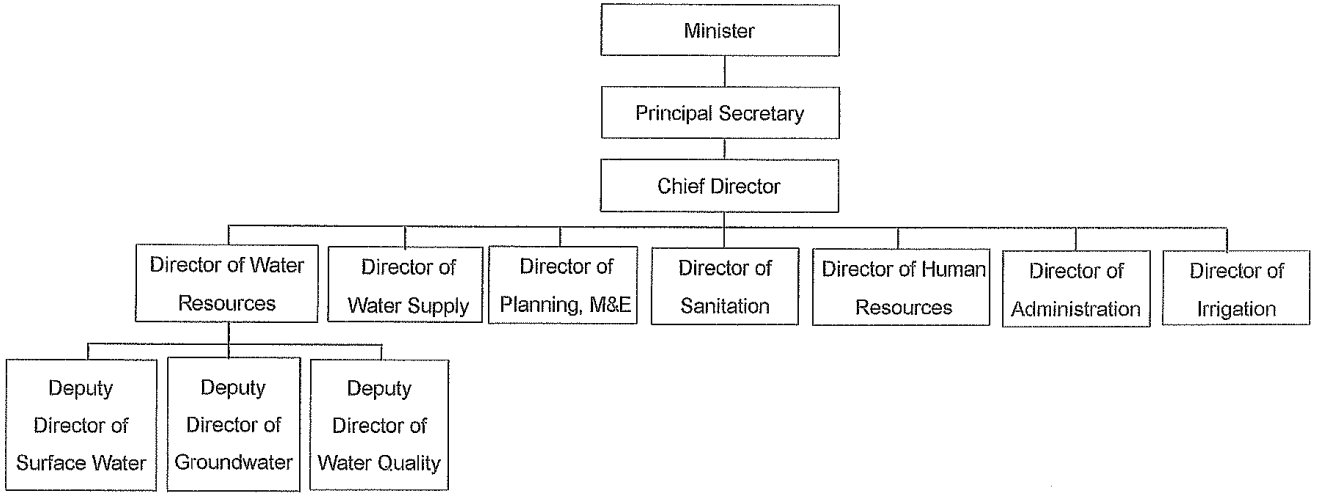
Annex 1

Project Site



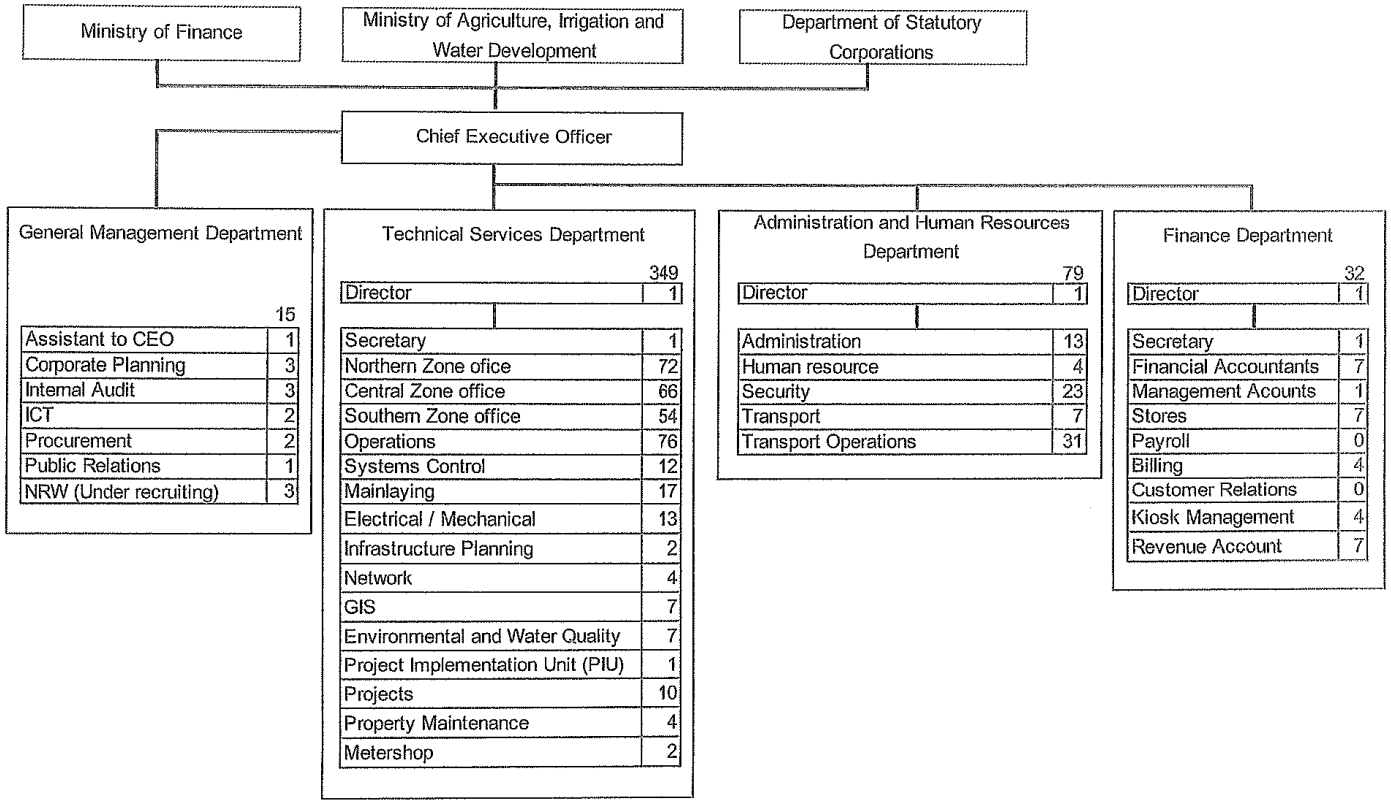
Annex 2

Organization Chart (Ministry of Agriculture, Irrigation and Water Development)



Annex 2

Organization Chart (Lilongwe Water Board)



JAPANESE GRANT

The Japanese Grant is non-reimbursable fund provided to a recipient country (hereinafter referred to as "the Recipient") to purchase the products and/or services (engineering services and transportation of the products, etc.) for its economic and social development in accordance with the relevant laws and regulations of Japan. Followings are the basic features of the project grants operated by JICA (hereinafter referred to as "Project Grants").

1. Procedures of Project Grants

Project Grants are conducted through following procedures (See "PROCEDURES OF JAPANESE GRANT" for details):

(1) Preparation

- The Preparatory Survey (hereinafter referred to as "the Survey") conducted by JICA

(2) Appraisal

-Appraisal by the government of Japan (hereinafter referred to as "GOJ") and JICA, and Approval by the Japanese Cabinet

(3) Implementation

Exchange of Notes

-The Notes exchanged between the GOJ and the government of the Recipient

Grant Agreement (hereinafter referred to as "the G/A")

-Agreement concluded between JICA and the Recipient

Banking Arrangement (hereinafter referred to as "the B/A")

-Opening of bank account by the Recipient in a bank in Japan (hereinafter referred to as "the Bank") to receive the grant

Construction works/procurement

-Implementation of the project (hereinafter referred to as "the Project") on the basis of the G/A

(4) Ex-post Monitoring and Evaluation

-Monitoring and evaluation at post-implementation stage

2. Preparatory Survey

(1) Contents of the Survey

The aim of the Survey is to provide basic documents necessary for the appraisal of the the Project made by the GOJ and JICA. The contents of the Survey are as follows:

- Confirmation of the background, objectives, and benefits of the Project and also institutional capacity of

relevant agencies of the Recipient necessary for the implementation of the Project.

- Evaluation of the feasibility of the Project to be implemented under the Japanese Grant from a technical, financial, social and economic point of view.
- Confirmation of items agreed between both parties concerning the basic concept of the Project.
- Preparation of an outline design of the Project.
- Estimation of costs of the Project.
- Confirmation of Environmental and Social Considerations

The contents of the original request by the Recipient are not necessarily approved in their initial form. The Outline Design of the Project is confirmed based on the guidelines of the Japanese Grant.

JICA requests the Recipient to take measures necessary to achieve its self-reliance in the implementation of the Project. Such measures must be guaranteed even though they may fall outside of the jurisdiction of the executing agency of the Project. Therefore, the contents of the Project are confirmed by all relevant organizations of the Recipient based on the Minutes of Discussions.

(2) Selection of Consultants

For smooth implementation of the Survey, JICA contracts with (a) consulting firm(s). JICA selects (a) firm(s) based on proposals submitted by interested firms.

(3) Result of the Survey

JICA reviews the report on the results of the Survey and recommends the GOJ to appraise the implementation of the Project after confirming the feasibility of the Project.

3. Basic Principles of Project Grants

(1) Implementation Stage

1) The E/N and the G/A

After the Project is approved by the Cabinet of Japan, the Exchange of Notes (hereinafter referred to as "the E/N") will be singed between the GOJ and the Government of the Recipient to make a pledge for assistance, which is followed by the conclusion of the G/A between JICA and the Recipient to define the necessary articles, in accordance with the E/N, to implement the Project, such as conditions of disbursement, responsibilities of the Recipient, and procurement conditions. The terms and conditions generally applicable to the Japanese Grant are stipulated in the "General Terms and Conditions for Japanese Grant (January 2016)."

2) Banking Arrangements (B/A) (See "Financial Flow of Japanese Grant (A/P Type)" for details)

a) The Recipient shall open an account or shall cause its designated authority to open an account under the name of the Recipient in the Bank, in principle. JICA will disburse the Japanese Grant in Japanese yen for the Recipient to cover the obligations incurred by the Recipient under the verified contracts.

b) The Japanese Grant will be disbursed when payment requests are submitted by the Bank to JICA under an Authorization to Pay (A/P) issued by the Recipient.

3) Procurement Procedure

The products and/or services necessary for the implementation of the Project shall be procured in accordance with JICA's procurement guidelines as stipulated in the G/A.

4) Selection of Consultants

In order to maintain technical consistency, the consulting firm(s) which conducted the Survey will be recommended by JICA to the Recipient to continue to work on the Project's implementation after the E/N and G/A.

5) Eligible source country

In using the Japanese Grant disbursed by JICA for the purchase of products and/or services, the eligible source countries of such products and/or services shall be Japan and/or the Recipient. The Japanese Grant may be used for the purchase of the products and/or services of a third country as eligible, if necessary, taking into account the quality, competitiveness and economic rationality of products and/or services necessary for achieving the objective of the Project. However, the prime contractors, namely, constructing and procurement firms, and the prime consulting firm, which enter into contracts with the Recipient, are limited to "Japanese nationals", in principle.

6) Contracts and Concurrence by JICA

The Recipient will conclude contracts denominated in Japanese yen with Japanese nationals. Those contracts shall be concurred by JICA in order to be verified as eligible for using the Japanese Grant.

7) Monitoring

The Recipient is required to take their initiative to carefully monitor the progress of the Project in order to ensure its smooth implementation as part of their responsibility in the G/A, and to regularly report to JICA about its status by using the Project Monitoring Report (PMR).

8) Safety Measures

The Recipient must ensure that the safety is highly observed during the implementation of the Project.

9) Construction Quality Control Meeting

Construction Quality Control Meeting (hereinafter referred to as the "Meeting") will be held for quality assurance and smooth implementation of the Works at each stage of the Works. The member of the Meeting will be composed by the

Recipient (or executing agency), the Consultant, the Contractor and JICA. The functions of the Meeting are as followings:

a) Sharing information on the objective, concept and conditions of design from the Contractor, before start of construction.

b) Discussing the issues affecting the Works such as modification of the design, test, inspection, safety control and the Client's obligation, during of construction.

(2) Ex-post Monitoring and Evaluation Stage

1) After the project completion, JICA will continue to keep in close contact with the Recipient in order to monitor that the outputs of the Project is used and maintained properly to attain its expected outcomes.

2) In principle, JICA will conduct ex-post evaluation of the Project after three years from the completion. It is required for the Recipient to furnish any necessary information as JICA may reasonably request.

(3) Others

1) Environmental and Social Considerations

The Recipient shall carefully consider environmental and social impacts by the Project and must comply with the environmental regulations of the Recipient and JICA Guidelines for Environmental and Social Considerations (April, 2010).

2) Major undertakings to be taken by the Government of the Recipient

For the smooth and proper implementation of the Project, the Recipient is required to undertake necessary measures including land acquisition, and bear an advising commission of the A/P and payment commissions paid to the Bank as agreed with the GOJ and/or JICA. The Government of the Recipient shall ensure that customs duties, internal taxes and other fiscal levies which may be imposed in the Recipient with respect to the purchase of the Products and/or the Services be exempted or be borne by its designated authority without using the Grant and its accrued interest, since the grant fund comes from the Japanese taxpayers.

3) Proper Use

The Recipient is required to maintain and use properly and effectively the products and/or services under the Project (including the facilities constructed and the equipment purchased), to assign staff necessary for this operation and maintenance and to bear all the expenses other than those covered by the Japanese Grant.

4) Export and Re-export

The products purchased under the Japanese Grant should not be exported or re-exported from the Recipient.

Attachment 1

PROCEDURES OF JAPANESE GRANT

Stage	Procedures	Remarks	Recipient Government	Japanese Government	JICA	Consultants	Contractors	Agent Bank
Official Request	Request for grants through diplomatic channel	Request shall be submitted before appraisal stage.	x	x				
1. Preparation	(1) Preparatory Survey Preparation of outline design and cost estimate		x		x	x		
2. Appraisal	(2)Preparatory Survey Explanation of draft outline design, including cost estimate, undertakings, etc.		x		x	x		
	(3)Agreement on conditions for implementation	Conditions will be explained with the draft notes (E/N) and Grant Agreement (G/A) which will be signed before approval by Japanese government.	x	x (E/N)	x (G/A)			
	(4) Approval by the Japanese cabinet			x				
3. Implementation	(5) Exchange of Notes (E/N)		x	x				
	(6) Signing of Grant Agreement (G/A)		x		x			
	(7) Banking Arrangement (B/A)	Need to be informed to JICA	x					x
	(8) Contracting with consultant and issuance of Authorization to Pay (A/P)	Concurrence by JICA is required	x			x		x
	(9) Detail design (D/D)		x			x		
	(10) Preparation of bidding documents	Concurrence by JICA is required	x			x		
	(11) Bidding	Concurrence by JICA is required	x			x	x	
	(12) Contracting with contractor/supplier and issuance of A/P	Concurrence by JICA is required	x				x	x
	(13) Construction works/procurement	Concurrence by JICA is required for major modification of design and amendment of contracts.	x			x	x	
	(14) Completion certificate		x			x	x	
4. Ex-post monitoring & evaluation	(15) Ex-post monitoring	To be implemented generally after 1, 3, 10 years of completion, subject to change	x		x			
	(16) Ex-post evaluation	To be implemented basically after 3 years of completion	x		x			

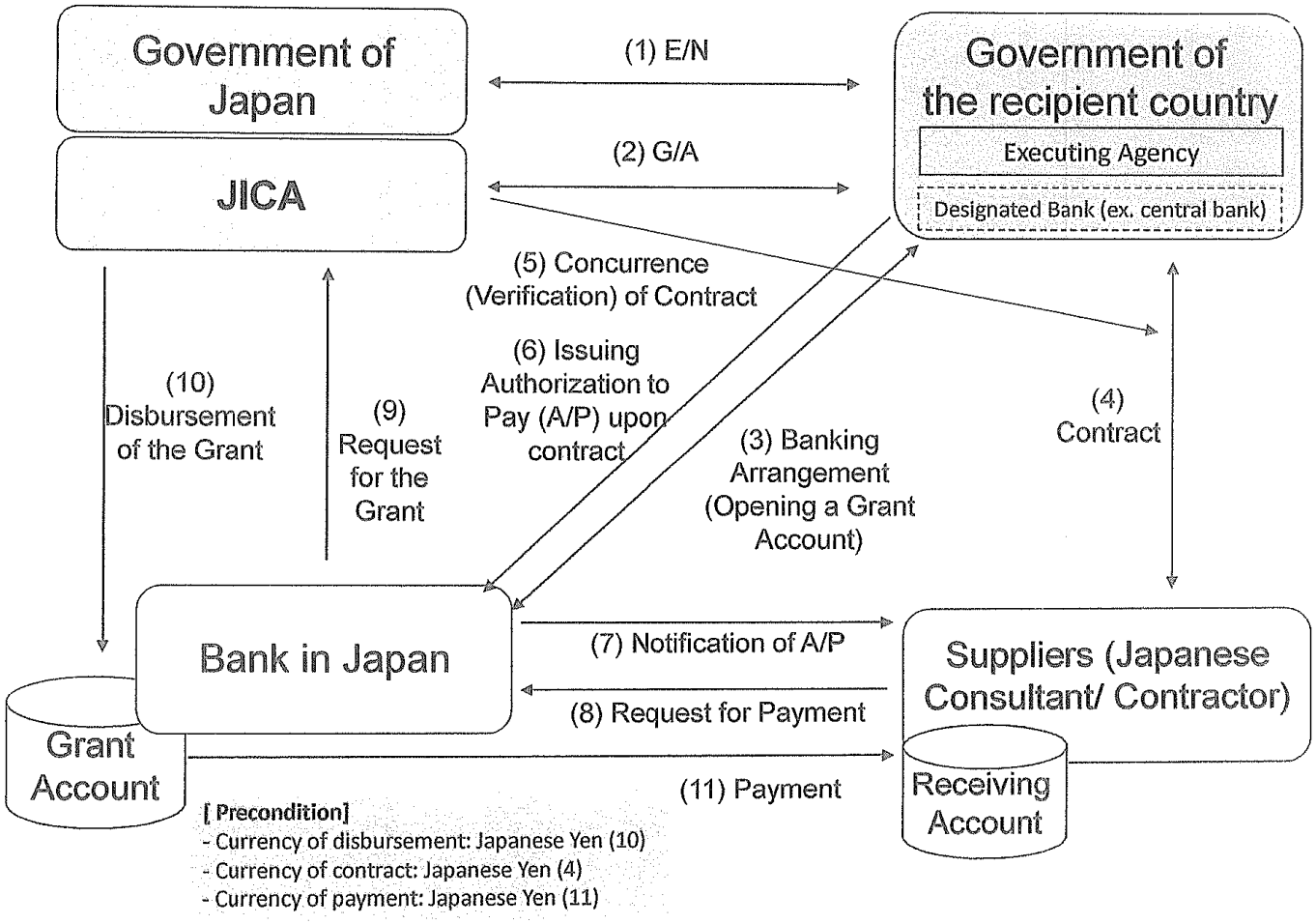
notes:

1. Project Monitoring Report and Report for Project Completion shall be submitted to JICA as agreed in the G/A.

2. Concurrence by JICA is required for allocation of grant for remaining amount and/or contingencies as agreed in the G/A.

Attachment 2

Financial Flow of Japanese Grant (A/P Type)



Project Monitoring Report
on
Project Name
Grant Agreement No. XXXXXXX
20XX, Month

Organizational Information

Signer of the G/A (Recipient)	Person in Charge	(Designation)
	Contacts	Address: Phone/FAX: Email:
Executing Agency	Person in Charge	(Designation)
	Contacts	Address: Phone/FAX: Email:
Line Ministry	Person in Charge	(Designation)
	Contacts	Address: Phone/FAX: Email:

General Information:

Project Title	
E/N	Signed date: Duration:
G/A	Signed date: Duration:
Source of Finance	Government of Japan: Not exceeding JPY _____ mil. Government of (_____): _____

1: Project Description

1-1 Project Objective

1-2 Project Rationale

- Higher-level objectives to which the project contributes (national/regional/sectoral policies and strategies)
- Situation of the target groups to which the project addresses

1-3 Indicators for measurement of "Effectiveness"

Quantitative indicators to measure the attainment of project objectives		
Indicators	Original (Yr)	Target (Yr)
Qualitative indicators to measure the attainment of project objectives		

2: Details of the Project

2-1 Location

Components	Original *(proposed in the outline design)*	Actual
1.		

2-2 Scope of the work

Components	Original* *(proposed in the outline design)*	Actual*
1.		

Reasons for modification of scope (if any).

(PMR)

2-3 Implementation Schedule

Items	Original		Actual
	(proposed in the outline design)	*(at the time of signing the Grant Agreement)*	

Reasons for any changes of the schedule, and their effects on the project (if any)

2-4 Obligations by the Recipient

2-4-1 Progress of Specific Obligations

See Attachment 2.

2-4-2 Activities

See Attachment 3.

2-4-3 Report on RD

See Attachment 11.

2-5 Project Cost

2-5-1 Cost borne by the Grant(Confidential until the Bidding)

Components			Cost (Million Yen)	
	Original *(proposed in the outline design)*	Actual *(in case of any modification)*	Original[1),2)] *(proposed in the outline design)*	Actual
	1.			
Total				

Note: 1) Date of estimation:
2) Exchange rate: 1 US Dollar = Yen

2-5-2 Cost borne by the Recipient

Components			Cost (1,000 Taka)	
	Original *(proposed in the outline design)*	Actual *(in case of any modification)*	Original[1),2)] *(proposed in the outline design)*	Actual
	1.			

Note: 1) Date of estimation:
2) Exchange rate: 1 US Dollar =

Reasons for the remarkable gaps between the original and actual cost, and the countermeasures (if any)

(PMR)

2-6 Executing Agency

- Organization's role, financial position, capacity, cost recovery etc,
- Organization Chart including the unit in charge of the implementation and number of employees.

Original *(at the time of outline design)* name: role: financial situation: institutional and organizational arrangement (organogram): human resources (number and ability of staff):
Actual *(PMR)*

2-7 **Environmental and Social Impacts**

- The results of environmental monitoring based on Attachment 5 (in accordance with Schedule 4 of the Grant Agreement).
- The results of social monitoring based on in Attachment 5 (in accordance with Schedule 4 of the Grant Agreement).
- Disclosed information related to results of environmental and social monitoring to local stakeholders (whenever applicable).

3: Operation and Maintenance (O&M)

3-1 Physical Arrangement

- Plan for O&M (number and skills of the staff in the responsible division or section, availability of manuals and guidelines, availability of spareparts, etc.)

Original *(at the time of outline design)*
Actual *(PMR)*

3-2 Budgetary Arrangement

- Required O&M cost and actual budget allocation for O&M

Original *(at the time of outline design)*

Actual *(PMR)*

4: Potential Risks and Mitigation Measures

- Potential risks which may affect the project implementation, attainment of objectives, sustainability
- Mitigation measures corresponding to the potential risks

Assessment of Potential Risks *(at the time of outline design)*

Potential Risks	Assessment
1. (Description of Risk)	Probability: High/Moderate/Low
	Impact: High/Moderate/Low
	Analysis of Probability and Impact:
	Mitigation Measures:
	Action required during the implementation stage:
	Contingency Plan (if applicable):
2. (Description of Risk)	Probability: High/Moderate/Low
	Impact: High/Moderate/Low
	Analysis of Probability and Impact:
	Mitigation Measures:
	Action required during the implementation stage:
	Contingency Plan (if applicable):
3. (Description of Risk)	Probability: High/Moderate/Low
	Impact: High/Moderate/Low
	Analysis of Probability and Impact:
	Mitigation Measures:
	Action required during the implementation stage:
	Contingency Plan (if applicable):

Actual Situation and Countermeasures	
(PMR)	

5: Evaluation and Monitoring Plan (after the work completion)

5-1 Overall evaluation

Please describe your overall evaluation on the project.

5-2 Lessons Learnt and Recommendations

Please raise any lessons learned from the project experience, which might be valuable for the future assistance or similar type of projects, as well as any recommendations, which might be beneficial for better realization of the project effect, impact and assurance of sustainability.

5-3 Monitoring Plan of the Indicators for Post-Evaluation

Please describe monitoring methods, section(s)/department(s) in charge of monitoring, frequency, the term to monitor the indicators stipulated in 1-3.

Attachment

1. Project Location Map
2. Specific obligations of the Recipient which will not be funded with the Grant
3. Monthly Report submitted by the Consultant

Appendix - Photocopy of Contractor's Progress Report (if any)
- Consultant Member List
- Contractor's Main Staff List

4. Check list for the Contract (including Record of Amendment of the Contract/Agreement and Schedule of Payment)
5. Environmental Monitoring Form / Social Monitoring Form
6. Monitoring sheet on price of specified materials (Quarterly)
7. Report on Proportion of Procurement (Recipient Country, Japan and Third Countries) (PMR (final)only)
8. Pictures (by JPEG style by CD-R) (PMR (final)only)
9. Equipment List (PMR (final)only)
10. Drawing (PMR (final)only)
11. Report on RD (After project)

Attachment 6

Monitoring sheet on price of specified materials

1. Initial Conditions (Confirmed)

	Items of Specified Materials	Initial Volume A	Initial Unit Price (¥) B	Initial total Price C=A×B	1% of Contract Price D	Condition of payment	
						Price (Decreased) E=C−D	Price (Increased) F=C+D
1	Item 1	●●t	●	●	●	●	●
2	Item 2	●●t	●	●	●		
3	Item 3						
4	Item 4						
5	Item 5						

2. Monitoring of the Unit Price of Specified Materials

(1) Method of Monitoring : ●●

(2) Result of the Monitoring Survey on Unit Price for each specified materials

	Items of Specified Materials	1st ●month, 2015	2nd ●month, 2015	3rd ●month, 2015	4th	5th	6th
1	Item 1						
2	Item 2						
3	Item 3						
4	Item 4						
5	Item 5						

(3) Summary of Discussion with Contractor (if necessary)

-

-

-

Attachment 7

Report on Proportion of Procurement (Recipient Country, Japan and Third Countries)
(Actual Expenditure by Construction and Equipment each)

	Domestic Procurement (Recipient Country) A	Foreign Procurement (Japan) B	Foreign Procurement (Third Countries) C	Total D
Construction Cost	(A/D%)	(B/D%)	(C/D%)	
Direct Construction Cost	(A/D%)	(B/D%)	(C/D%)	
others	(A/D%)	(B/D%)	(C/D%)	
Equipment Cost	(A/D%)	(B/D%)	(C/D%)	
Design and Supervision Cost	(A/D%)	(B/D%)	(C/D%)	
Total	(A/D%)	(B/D%)	(C/D%)	

Annex 5

Major Undertakings to be taken by the Government of Malawi

1. Specific obligations of the Government of Malawi which will not be funded with the Grant

(1) Before the Tender

NO	Items	Deadline	In charge	Estimated Cost	Ref.
1	To open bank account (B/A)	within 1 month after the signing of the G/A	MoFEPD / MAIWD		
2	To issue A/P to a bank in Japan (the Agent Bank) for the payment to the consultant	within 1 month after the signing of the contract	MoFEPD / MAIWD		
6	To secure space for equipment	before notice of the bidding document	MAIWD / LWB		
9	To submit Project Monitoring Report (with the result of Detail Design)	before preparation of bidding documents	MAIWD / LWB		

(B/A: Banking Arrangement, A/P: Authorization to pay, N/A: Not Applicable, MoFEPD: Ministry of Finance, Economic Planning and Development, MAIWD: Ministry of Agriculture, Irrigation and Water Development, LWB: Lilongwe Water Board)

(2) During the Project Implementation

NO	Items	Deadline	In charge	Estimated Cost	Ref.
1	To issue A/P to a bank in Japan (the Agent Bank) for the payment to the Supplier(s)	within 1 month after the signing of the contract(s)	MoFEPD / MAIWD		
2	To bear the following commissions to a bank in Japan for the banking services based upon the B/A				
	1) Advising commission of A/P	within 1 month after the signing of the contract(s)	MoFEPD / MAIWD		
	2) Payment commission for A/P	every payment	MoFEPD / MAIWD		
3	To ensure prompt customs clearance and to assist the Supplier(s) with internal transportation in recipient country	during the Project	MoFEPD / MAIWD		
4	To accord Japanese nationals and/or physical persons of third countries whose services may be required in connection with the supply of the products and the services such facilities as may be necessary for their entry into the country of the Recipient and stay therein for the performance of their work	during the Project	MoFEPD / MAIWD		
5	To ensure that customs duties, internal taxes and other fiscal levies which may be imposed in the country of the Recipient with respect to the purchase of the products and/or the services be exempted;	during the Project	MoFEPD / MAIWD		
6	To bear all the expenses, other than those covered by the Grant, necessary for the implementation of the Project	during the Project	MAIWD / LWB		
7	To submit Project Monitoring Report after each work under the contract(s) such as shipping, hand over, installation and operational training	within one month after completion of each work	MAIWD / LWB		
	1) To submit Project Monitoring Report (final)	within one month after signing of Certificate of Completion for the works under the contract(s)	MAIWD / LWB		
8	To submit a report concerning completion of the Project	within six months after completion of the Project	MAIWD / LWB		

(3) After the Project

NO	Items	Deadline	In charge	Estimated Cost	Ref.
3	To maintain and use properly and effectively the facilities constructed and equipment provided under the Grant Aid 1) Allocation of maintenance cost 2) Operation and maintenance structure 3) Routine check/Periodic inspection	After completion of the construction	MAIWD / LWB		

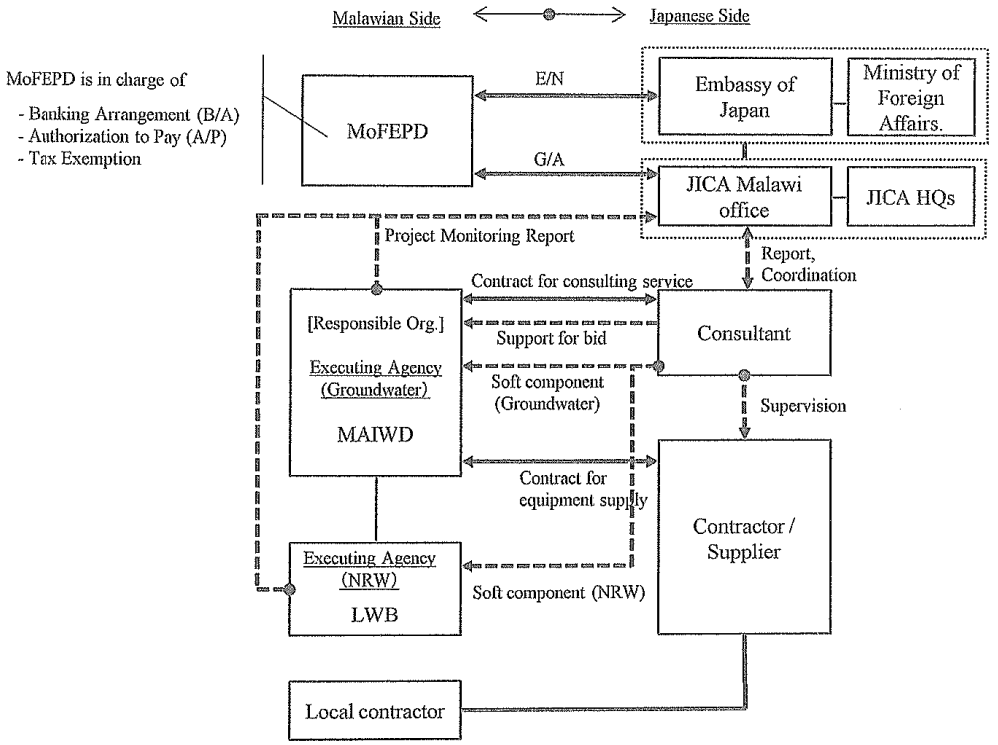
2. Other obligations of the Government of Malawi funded with the Grant

NO	Items	Deadline	Amount (Million Japanese Yen)*
1	To provide equipment with installation and commissioning		
2	To implement detailed design, bidding support and procurement supervision (Consulting Service)		
	Total		XXX

*The Amount is provisional. This is subject to the approval of the Government of Japan.

Annex 6

Implementation Structure



Technical Notes on 10th August 2017

TECHNICAL NOTES
ON
THE PREPARATORY SURVEY
ON
THE PROJECT FOR IMPROVEMENT OF GROUNDWATER DEVELOPMENT AND NON-REVENUE WATER REDUCTION IN MALAWI

Based on the Minutes of Discussions signed on the 20th of July 2017 between the Preparatory Survey Team (hereinafter referred to as "the Team") of Japan International Cooperation Agency (hereinafter referred to as "JICA") and Ministry of Agriculture, Irrigation and Water Development (hereinafter referred to as "MAIWD") and Lilongwe Water Board (hereinafter referred to as "LWB") on the Project for Improvement of Groundwater Development and Non-Revenue Water Reduction (hereinafter referred to as "the Project"), the Consultant members of the Team had a series of discussions and conducted the field survey from the 16th of July to the 10th of August 2017.

Based on the discussions and field survey, Malawian sides (MAIWD and LWB) and the Team (hereinafter referred to as "both sides") confirmed the technical conditions described in the attached sheets.

The detail of the contents of the Project shall be decided upon further surveys and discussion between both sides.

Lilongwe, August 10, 2017

Mrs. Modesta B. KANJAYE
Director
Department of Water Resources
Ministry of Agriculture, Irrigation and Water Development
Malawi

Takeshi NAKANO
Chief Consultant
Preparatory Survey Team
Kokusai Kogyo Co., Ltd.
Japan

Eng. Alfonso CHIKUNI
Chief Executive Officer
Lilongwe Water Board
Malawi

ATTACHMENT

1. Pre-conditions for Scoping the Project

Both sides clarified and confirmed the pre-conditions for scoping the Project through the field survey, careful readings of existing documents and discussions with concerned organizations, as mentioned below.

1-1 Groundwater Development

1-1-1 Concrete Plan for Groundwater Development

MAIWD recognized the necessity of groundwater development through boreholes of 100 m or deeper because there are challenges of the water quality (the existence of salty water) and low yields found at current shallow aquifers. Thus, MAIWD have an intention to place the priority on the construction of deeper wells at 32 market centers and communities, which have faced the expansion of water demands. Nevertheless, concrete plans such as names and numbers of priority targeted localities for these deeper wells within 32 market centers and communities, were not found in any documents including "Malawi Rural Water Supply Investment Plan: 2014-2020" as MAIWD's overall plan.

1-1-2 Deeper Aquifers in Malawi

The Team confirmed that geophysical prospecting survey was conducted at 41 points (Max. 150 m depth) and 32 points (Max. 400 m depth) on existing survey reports, which are "Consultancy Services for National Hydrogeological and Water Quality Mapping Final Geophysical Survey Report (March 2015)" and "Hydrogeological and Water Quality Mapping Consultancy in Shire River Basin Draft Geophysical Survey Report (June 2017)". Based on results analysis of these reports by the Team, it is recognized that there is a possibility of the existence of deeper aquifers (deeper than 100 m) in several places in Malawi. However, there are no actual performances (drilling records) to drill deeper than 100 m in Malawi and thus, comparative examinations between drilling records and results of geophysical prospecting cannot be conducted at the moment. The sites with a possibility to develop deeper aquifers are shown in Annex-1.

1-1-3 Operation and Maintenance System for Equipment

The Team confirmed that MAIWD has a stable supply chain to purchase spare parts of drilling machinery, three (3) drilling teams consisted of skilled staffs and financial resources for well construction. Major financial resource is called "Borehole Construction and Groundwater Management Fund", which is utilized for sustainable operation and maintenance for drilling rigs, support tracks and other necessary equipment. The Existing Equipment List owned by MAIWD is referred to as Annex-2.

1-1-4 Operation and Maintenance System for Newly Developed Wells

MAIWD have an intention to place the priority on the construction of deeper wells at 32 market centers and communities as mentioned above 1-1-1. Newly developed wells at market centers will be operated and maintained by Water Boards, which have sufficient experiences of operating and maintaining existing wells at each area. While developing market centers, MAIWD also have an intention to develop deeper wells at community levels. These newly developed wells at community levels will be operated and maintained through communities as Water Users Association supported by Local Authorities.

1-1-5 Capacity to Drill Deeper than 100 m by Private Company

The Team confirmed that the private drilling companies in Malawi have no sufficient equipment and experiences to drill deeper than 100 m.

1-2 Non-Revenue Water Reduction

Both sides discussed the candidate equipment by utilizing "Simplified Water Supply Plan in Lilongwe City" prepared by the Team (referred to as Annex-3) and confirmed the contents in accordance with following points.

(1) Priority for non-revenue water reduction
(2) Contribution to roll out the output for "the Project for Strengthening the Capacity of Non-Revenue Water Reduction for Lilongwe Water Board"
(3) Immediate utilization on site
(4) No duplication with other development partners and proper sequence of the Projects to be followed

Both sides evaluated each candidate equipment as described in Annex-4 and agreed its contents.

2. Unit Integration

Both sides agreed that the units for the Project will be according to SI (International System).

3. Future Schedule

Both sides agreed and confirmed that survey results will be used for analysis in Japan, and the Team will make the Project designs and cost estimation. Draft equipment plan including cost estimation will be reported and explained to MAIWD and LWB by the Team around later in November 2017.

4. Official Request

Both sides re-confirmed that the Government of Malawi will submit an official request to the Government of Japan through a diplomatic channel before September 2017.

Annex:

[Groundwater Development]

1. The Sites with a Possibility to Develop Deeper Aquifers
2. Existing Equipment List owned by MAIWD

[Non-Revenue Water Reduction]

3. Simplified Water Supply Plan in Lilongwe City
4. Evaluation of the Candidate Equipment for Non-Revenue Water Reduction

Annex-1: The Sites with a Possibility to Develop Deeper Aquifers

Survey Point			Result of Geophysical Prospecting						Evaluation	
Region	District	Site Name	Survey Depth (m)	Predicted Aquifer Depth (m)	Resistivity (Ohm*m)	Hydrogeology	Groundwater Aquifer	Caution	Priority to develop	Target Depth (m)
Northern	Rumphi	Mzokoto	150	40~150	80~140	Weathered Rock or Fracture	Fissure		B	200
Northern	Nkhotakota	Kamphambale	150	80~150≦	30~85	Low Resistive Rocks	Fissure		A	200
Central	Kasungu	Lisandwa	150	80~150≦	1,400	Weathered Rock with Fracture	Fissure		A	200
Central	Lilongwe	Nanthenje	150	50~150≦	230~3,000	Weathered Rock with Fracture	Fissure		B	200
Southern	Mangochi	Chantulo	150	60~150≦	5~7	Low Resistivity Zone/Saline Aquifer	Stratum	*1	A	200
Southern	Machinga	Nselema-Button	150	50~150≦	120~920	Weathered Rock with Fracture	Fissure		B	200
Southern	Chikwawa	Ngabu	400	90~200	3~20	Unconsolidated Sediment	Stratum/Fracture		B	200
Southern	Chikwawa	Chambulika	400	60~180	35~65	Basalt Lava/Pyroclasitic Flow	Fissure		A	200
Southern	Balaka	Namalomba	400	100~300	5~10	Unconsolidated Sediment from Lake Malombe	Stratum	*1	A	200
Southern	Balaka	Buke	400	40~230	400~2,000	Weathered Gneiss/Fractures	Fissure		B	200
Southern	Chikhwawa	Mitondo	400	80~250	10~30	Unconsolidated Sediments	Stratum	*1	A	200
Southern	Chikhwawa	Namalidi	400	100~200	4~20	Unconsolidated Sediments from Shire River	Stratum		B	200

*1: Salty water may exist in the upper aquifer.

Annex-2: Existing Equipment List owned by MAIWD

No.	Reg. No.	Type	Manufacturer	Specification	Mileage	Quantity	Status	Remarks
1	021MG031	Drilling Rig	Koken	80 m depth drilling	2,552.5 hrs	1	Working	
			Hino		15,442.2 km			
2	MG586AA	Drilling Rig	YBM	80 m depth drilling	1,190.7 hrs	1	Working	
			Nissan UD		3,494.8 km			
3	MG254U	Drilling Rig	Koken	80 m depth drilling	N/A	1	Working	in the field
			Hino		N/A			
4	021MG200	Drilling Rig	Koken	80 m depth drilling	N/A	1	Under Repairs	
			Hino		N/A			
5		Hammer Bit		6 inch		3	Working	
				8-1/2 inch		6	Working	
6		Roller Bit		4 inch		3	Working	
				8-1/2 inch		3	Working	
7		Wing Bit		8-1/2 inch		3	Working	
8		Temporary Casing		8 inch, 3 m		30	Working	
9		Drill Rod				91	Working	
10	021MG035	Truck with Air Compressor	Hokuetsu	300 Mpa	868.2 hrs	1	Working	
			Hino		15,390.3 km			
11	021MG036	Truck with Air Compressor	Hokuetsu	300 Mpa	N/A	1	Working	in the field
			Hino		N/A			
12	021MG037	Truck with Air Compressor	Hokuetsu	300 Mpa	N/A	1	Under Repairs	in the field
			Hino		N/A			
13	MG587AA	Truck with Air Compressor	Hokuetsu	300 Mpa	1,550.0 hrs	1	Working	
			Nissan UD		4,117.3 km			
14	MG931P	Truck with Air Compressor	Hokuetsu	300 Mpa	N/A	1	Abandon	
			Hino		N/A		Working	
15	021MG097	Truck with Pumping Test Equipment	Hokuetsu	300 Mpa	N/A	1	Working	
			Hino		157,926.0 km			
16	MG583AA	Support Truck with Crane	Nissan UD	7 ton, 3 ton crane	187,823.0 km	1	Working	
17	MG584AA	Support Truck with Crane	Nissan UD	7 ton, 3 ton crane	148,501.0 km	1	Working	
18	MG585AA	Support Truck with Crane	Nissan UD	7 ton, 3 ton crane	110,000.0 km	1	Working	
19	021MG038	Support Truck	Hino	7 ton loading	N/A	1	Working	in the field
20	021MG014	Support Truck	Hino	7 ton loading	N/A	1	Working	in the field
21	021MG118	Mobile Workshop Truck	Mitsubishi	4 ton crane	82,178.0 km	1	Working	
22	021MG022	Tipper			63,684.0 km		Working	
23	021MG018	Water Bowser		6 m3	23,733.0 km	1	Working	
24		Water Bowser		6 m3	N/A	1	Working	in the field
25		Water Bowser		6 m3	N/A	1	Working	in the field
26		Dozer	Komatsu	D6	N/A	1	Working	in the field
27		Excavator			N/A	1	Working	in the field
28		Front-end Loader			N/A	1	Working	in the field
29	021MG039	Mobile Water Treatment Plant			2,002.0 km	1	Working	
30		Geophysical Prospecting Machine	Iris	150 m depth		2	Working	
31	021MG086	Drilling Rig	Hino			1	Abandon	
32	021MG201	Truck with Air Compressor	Nissan UD	300 Mpa		1	Abandon	
33	021MG085	Truck with Air Compressor	Hino	300 Mpa		1	Abandon	
34	021MG117	Support Truck with Crane	Isuzu	7 ton		1	Abandon	
35	021MG119	Support Truck with Crane	Hino	7 ton		1	Abandon	
36	MG251U	Support Truck with Crane	Hino	7 ton		1	Abandon	
37	MG252U	Support Truck	Hino	7 ton		1	Abandon	

As of August 4, 2017

Annex-3

Simplified Water Supply Plan in Lilongwe City

This "Simplified Water Supply Plan" is established to contribute to clarify the challenges of improvement of current water supply situation in Lilongwe referring to the strategic issues written in "Strategic Plan 2015-2020" as follows.

- Request by Implementation Agency
- Consistency with Plan and Strategy
- Current Status of existing facilities and equipment
- Status of operation and maintenance
- Overlap of other project (JICA and/or other donors)

The Simplified Water Supply Plan

1 The strategic plan and target Year :

The general water supply plan conform to the Strategic Plan 2015-2020 which is aligned to the Post Millennium Development Agenda, Malawi Growth and Development Strategy (MGDS) II, National Water Policy and the National Sanitation Policy.

The strategic issues consist of the following issues.

i. Unreliable water supply service
ii. Weak customer relations
iii. Limited financial capacity for infrastructure development
iv. Inadequate institutional capacity

Target year is set to 2020 based on the above Strategic Plan 2015-2020.

2 Planned Water Supply Area :

Planned water supply area in Lilongwe city to be focused are the current designated area with 106 Distributed Metered Areas (hereinafter, DMAs), which are current number in July 2017 by GIS data of Lilongwe Water Board (hereinafter, LWB), and to be expanded DMAs until 2020.

Number of Area & DMA

Zone Office	Area No.		DMA No.	
	Jun'17	July'17	Jun'17	July'17
North	19	19	31	49
Central	28	28	36	36
South	14	16	21	21
Total	**61**	**64**	**88**	**106**

*Data of "July'17" is based on GIS data of LWB

3 Water Demand Forecast and Planned Water Supply Volume :

The 2015 population of the city was approximately 1.04 million inhabitants and was expected to increase to 1.10 million inhabitants in 2016. The corresponding water demand for the city was estimated to have been 75,000m3/day in the year 2013 and was projected to grow to 110,000m3/day by 2016. While the demand seems lower than the LWB capacity to supply, the Non-Revenue Water (hereinafter, NRW) figures stand at a rolling average of 36% (45,000m3/day) of the total production capacity (125,000m3/day). Therefore, only 80,000m3/day is available for consumption.

The Strategic Plan 2015-2020 hold up achievements through the following objectives, including the NRW reduction.

- ✓ To provide adequate 24 hour supply at adequate pressure and quality.
- ✓ To increase supply coverage from 70% to 80%.
  (Improve supply to low income area, implementing individual connections, etc.)

4 Improvement of Water source and production :

Project of Kamuzu Dam which is comprised retaining wall rising (H=5.0m approx.) of Kamuzu-1 (water storage capacity 4.5Mm3) and rehabilitation of Kamuzu-2 (water storage capacity 19.8Mm3) is planned by the European Investment Bank (hereinafter, EIB) to increase water source capacity.

Water product under progress as WT-2-B project (WT-2, phase-2) and planned extension of water treatment plant such as WT-3 which has been announced tender of PPP project by World Bank.

The project for rehabilitation and expansion of the transmission and distribution pipe network is to be done by World Bank and EIB.

Intake of the water treatment plant such as WT-1 & 2 is to be maintained (dredged) periodically by LWB to keep function of water intake volume.

Water Sources and Water Treatment Plants

Facility	Name	Capacity	Established	Remarks
Water Source	Kamuzu-1	4.5Mm3	1966	
	Kamuzu-2	19.8Mm3	1981/1999	
	Sub-Total	24.3Mm3	-	
	Kamuzu-1 (Plan)	19.6Mm3	(2018~?)	By wall rising
	Total	43.9Mm3	-	
Water	TW-1	35,000m3/d	1966	

Treatment Plant (TW)	TW-2-A	60,000m3/d	1991	
	TW-2-B	30,000m3/d	(2017~?)	Under construction
	Sub-Total	125,000m3/d	-	
	TW-3	?	?	On tender notice
	Total	125,000++	-	

Source : Infrastructure Investment Plan for LWB, Tender notice of W.B.

5 Non-Revenue Water Management Plan :

LWB placed the parameter of the Non-Revenue Water to be reduced from 36% to 28 % by the target year 2020. New section such as "NRW Team" is to be established in this financial year of 2017 to reinforce and accelerate the NRW reduction through the improvement of leakage detection, illegal connection, inaccurate meter readings, etc.

"NRW Team" is to be reinforced of technical skills and satisficed equipment with support by the donors.

"NRW Team" shall have a close collaboration with the whole branch offices to offer, share, expand their technical skills for efficient water management to reduce NRW.

Also, "NRW Team", whole branch offices and concerned divisions shall have a close collaboration with GIS section to update GIS data, Map and share these data and documents.

6 Facility Construction / Equipment Procurement Plan :

LWB has the plans for increasing, upgrading in term of the Vision, Mission and Motto. The current principal project has been preparing as follows.

① Pipe network project (Expansion, Rehabilitation) which is to be done by World Bank and/or EIB.

② New water treatment plant project (New facility as WT-3) which is to be done by World Bank.

③ Equipment procurement for the NRW reduction which is expected to be done by JICA.

④ Improvement of work quality (e.g. QMS leading to ISO 9001, etc.) and customer responsive manner (e.g. Customer call center system, etc.) which is to be done by LWB.

⑤ Decent and stable income (e.g. charge collection system by pre-paid system, etc.) which is to be done by LWB.

7 Operation and Maintenance Plan :

In accordance with the "Theme Four, Internal Processes", 3.3 Strategic Goals, Objectives and Strategies in the Strategic Plan 2015-2020, an

improvement of staff productivity as one of the objective is advocated. Therefore, in term of efficient operation of water supply facilities, Operation and Maintenance shall be reinforced as priority such to be done by technical project as follows.

- Isolation of DMA, Reinforcement of the caretakers works, etc. which are being supported by Vitens Evides International to improvement operation and maintenance of water supply networks. (2015-2019)
- Technical cooperation for strengthening of the NRW reduction by JICA (2018-).

Strengthening the capacity of staff through various training intervention, for them to be able to deliver efficiently and effectivity.

8 Conclusion :

LWB has on-going and future project to improve current water supply situation in Lilongwe. However, the plan of equipment procurement for daily maintenance and minor repair to contribute the NRW reduction does not exist at the present even though it has urgency and immediate effect.

Therefore, such project is to be prioritized. Also utilization of procured equipment and material may contribute to the effective implementation of the Technical cooperation for strengthening of the NRW reduction by JICA.

EOF

Annex-4:

Evaluation of the Candidate Equipment for Non-Revenue Water Reduction

* Q'ty of each item is to be considered

No.	Category	ID No.	Current Screening		Name	Purpose	Specification (Tentative)	Power Supply (Tentative)	Remarks
1	Piping Connection	101	○		Pipe Drilling Tools	Hole drilling for clamp saddle connection on the pressured water pipe	appropriate for PVC, Polyethylene (PE), Asbests(AC) and Ductile (DIP) pipe, Drilling Dia. 15~50mm	Manual with rachet wrench	tool box which contains necessary parts and accessories to drill pipes of DN from 25 to 160mm.
2		102	×	To be Excepted	Clamp Saddle	Branch pipe connector from distribution pipe to house connection pipe	BS standard, ND 15mm-400mm	nil.	LWD is able to procure usually
3		103	○		Pipe Threading Tool	Threading of Galvanized Steel Pipe	BS standard. Set of tools for DN 15~75mm. Pipe Jack and Tripot Stand include	Manual with rachet wrench	To be supplied with at least a pair of toll for each diameter.
4		104	×	To be Excepted	Butte Welding Machine	Melt welding connection for Polypropylene Pipes	For Butte welding of PEHD pipes and fittings widiameters of 40mm to 200mm, 220-240Volt, 50Hz, Single Phase	220-240Volt, 50Hz, Single Phase	PE of big dia meter is not yet populared
5		105	○		Pipe Cutter	Pipe cutting	For Asbestos & Ductile Pipe Maximum cutting depth 100-130mm, Cutting Blade Dia. 350-400mm	Forced Air-cooled 2 stroke Gasoline Engine 3.0~4.0kw	To be supplied with at least 20 blades for each type of pipes
6		106	○		Lifting Tools for pipes and Velves	Hanging, Fixing of heavy pipes, Valves	Lift capacity 1.0~2.0 ton (approx.)	Manual	
7		107	○		Generator	Power supply for elec. tools, pumps, lights	1.5~2.5, 3.5~4.5kva, 220-240Volt, 50Hz, Single & ThreePhase, 2~3 Outputs terminals(BF Type) with circuit breaker	Forced Air-cooled 4 stroke Gasoline Engine	
8		108	○		Welding Machine	Welding steel material、Steel Pipes	Current Lange 30~190Amp, DC output 3.5-5.0kw, Applicable Electrode dia.2.0-4.5mm	Forced Air-cooled 4 stroke Gasoline Engine	Cable s , Clamp Holders
9		109	○		Tools	Tool set for machine, equipment and piping works	Wrench set (8mm-32mm), Strap Wrench up to dia. 300mm, Box Wrench set (8mm-32mm), Screw Drivers (+ & -), Strap Pipe Wrench dia.300mm, Pipe Wrench 100mm, Adjustable Wrench 20mm&50mm	nil.	
10		110	○		Compactor (Rammer / Plate Compactor / Hand Compactor)	Compaction of backfilling soil in pipe trench	・Inpact force 9-12kN, Plate width 250-300mm ・Centrifugal force 10-13kN, Plate width 300-400mm ・Iron weight with handle shaft	Forced air cooled Gasoline Engine / Manual	
11		111	○		Small (Mini) excavator (Rubber track Type)	Excavation of narrow pipe trench	Rated Net Engine Power (ISO9247/EEC80/1269 (17.0-18.0kw 22-25hp approx.), Dig Depth 2.5-2.8m.	Forced Water-cooled Diesel Engine 17-20kw	with Dozer Brade
12		112	○		Truck with Crane	Toransporting and loading of equipment	Crane capacity 2.5-3.0ton at 2.8-3.3m max. Crane length 2.8-3.3m min.~5.0-6.0m max. 4 wheel drive	Forced Water-cooled Diesel Engine 150-170kw 650-750N.M	
13		115	○		Engine Pump	Draining water of leakage	Connection dia 50mm, Total Head 25-30 Delivery Volume 500-700L/min., Max Suction Lift 6-8m	Forced Air-cooled 4 stroke Gasoline Engine	
14		118	○		Lighting Gear	Site works during night	LED 50watts, 3500~6000Lumen, Water Proof	220-240Volt, 50Hz, Single Phase	It to be ristricted urgent pipe repair works during night works in term of shorten suspended water supply and customer satisfaction.
15		119	○		Pipe & Fittings (Repair Clamp & Color Joint)	Pipe quick repair and connection (Repair Clamp / Color Joint)	ISO 1452, PN16 bars, for PVC, DIP, AC, Steel Pipe	nil.	It to be ristricted urgent pipe repair works in term of shorten suspended water supply and customer satisfaction.
16		120	○	To be add.	Excavator & Loader (Tyre type)	Excavation and soil loading of pipe trench	Rated Net Engine Power (ISO9247/EEC80/1269 (65.0-75.0kw 90-95hp), Excavator Dig. Depth 5.5-6.0m, Loader Bucket capacity 0.9-1.9m3	Forced Water-cooled Diesel Engine 17-20kw	with Loader Backet with Safety Conopy
17		121	○	To be add.	Water Pressure Test	Leakage inspection of installed pipes		Fuel Engine	It is efficient to reduce water leakage on the pipe lines in term of NRW.
18		122	△	To be add.	Micro Tunnel Machine	Pipe installation under road crossing	LWB will submit detail of specification.		It is to be analyzed carefully in term of technical and economical efficiency, effectiveness, managing capacity,etc.

Annex-4:

Evaluation of the Candidate Equipment for Non-Revenue Water Reduction

* Q'ty of each item is to be considered

No.	Category	ID No.	Current Screening		Name	Purpose	Specification (Tentative)	Power Supply (Tentative)	Remarks
19	Leak Management	201	○		Leak Detection Tools	Inspection of leakage	Radio Communication by UHF 320MHz0.5W output	Battery, Main Unit, Pre-Amplifier, Pick-up Sensor	
20		202	×	To be Excepted	Portable Ultrasonic Flow Meter	Measurement of pipe water flow	Velocity Range -30m-30m/s, Pipe Dia. ND13-5000mm	Battery	LWB has already 15 nos. It can be used with technical training by the expert.
21		203	○		Water Pressure Meter	Measurement of pipe water pressure	(Water pressure 0-2Mpa., Body should be Waterproof.	nil.	
22		204	○		Leak Sound Detection Bar	Leak detection survey		nil.	
23		205	○		Sound Water Pipe Locator	Pipe line survey	Frequency 50~500Hz approx.	Battery, Oscillator, Amplifier, Sensor	
24		206	×	To be Excepted	Potable GPS	Correcting accuracy location of pipelines		Dry Battery	
25		207	×	To be Excepted	Pressure Reduce Valve	Pressure reduce each DMA pipe network area	PN16	nil.	It is urgent matter to install at remaining DMA by LWB.
26	Management & Inspection	301	○		Accuracy Tester of Water Meter			Battery	
27		302	○		Pressure Gauge for Water Faucet	Monitoring of pipe pressure		Dry Battery	
28		303	○		Pickup Truck	Transportation of equipment and material	Single or Double Cabin, 2*4 or 4:4 drive	Forced Air-cooled 4 stroke Diesel Engine	
29		304	○		Motorcycle	Site inspection, Meter Reading, etc.	Off road type 2 passengers 2 or 4 stroke gasoline engine 120-150cubic centimeter	Air-cooled 2 or 4 stroke gasoline Engine	
30		305	×	To be Excepted	Dredging Machine	Dredging at Intake in Lilongwe River	e.g. Long reach boom excavator ...etc.		It is possible to dred by manual dredge buckets and mini excavators. Access road to be constructed by LWB.
31		306	○	To be add.	Back Up Generator with automatic starter	Back Up for power supply of pumps at the Water Treatment Plants & Booster Pump Stns.such as emergency power supply.	LWB submit detail of specification. MCCB=Molded Case Circuit Breaker Engine, Generator, Control panel, Cable.	Forced Water-cooled Diesel Engine	Foundation, Installation and Connection are to be done by LWB.
32		307	△	To be add.	Service Truck	for repair and maitenance of machine in the fields.	LWB will submit detail of specification.		

Minutes of Discussions on 6th December 2017

Minutes of Discussions
on the Preparatory Survey for the Project for
Improvement of Ground Water Development and Non-Revenue Water Reduction
(Explanation on Draft Preparatory Survey Report)

With reference to the minutes of discussions signed between Ministry of Agriculture, Irrigation and Water Development, Lilongwe Water Board and the Japan International Cooperation Agency (hereinafter referred to as "JICA") on July 20, 2017 and in response to the request from the Government of the Republic of Malawi(hereinafter referred to as "Malawi") dated October 2, 2017, JICA dispatched the Preparatory Survey Team (hereinafter referred to as "the Team") for the explanation of Draft Preparatory Survey Report (hereinafter referred to as "the Draft Report") for the Project for Improvement of Ground Water Development and Non-Revenue Water Reduction(hereinafter referred to as "the Project"), headed by Mr. Sadanobu SAWARA, Senior Advisor from November 27, 2017 to December 6, 2017.

As a result of the discussions, both sides agreed on the main items described in the attached sheets.

Lilongwe, December 6, 2017

Mr. Sadanobu SAWARA
Leader
Preparatory Survey Team
Japan International Cooperation Agency
Japan

Mr. Gray S.V.K Nyandule Phiri
Principal Secretary
Ministry of Agriculture, Irrigation and Water Development
Malawi

Eng. Alfonso Chikuni
Chief Executive Officer
Lilongwe Water Board
Malawi

Mrs. Madalo Nyambose
Director
Debt and Aid Management Division
Ministry of Finance, Economic Planning and Development
Malawi

ATTACHMENT

1. Objective of the Project

   The objective of the Project was primarily to enhance implementing capacity for increasing drinking water in rural areas and improving water use efficiency in the capital city in Malawi by procuring and installing equipment for groundwater development and non-revenue water reduction, thereby contributing to improve water supply in Malawi.

   However, following the conclusion on the exclusion of Groundwater Development Component in the Article 16-2-2, both sides agreed that the objective of the Project now is to increase efficiency and effectiveness of Non-Revenue Water reduction activities in Lilongwe by procuring and installing equipment for Non-Revenue Water Reduction, thereby contributing to reduction of Non-Revenue Water and improvement of water supply service in Lilongwe.

2. Title of the Preparatory Survey

   Both sides confirmed the title of the Preparatory Survey as "the Preparatory Survey for the Project for Improvement of Ground Water Development and Non-Revenue Water Reduction".

3. Project site

   Both sides confirmed that the site of the Project is in Lilongwe, which is shown in Annex 1.

4. Responsible authority for the Project

   Both sides confirmed the authorities responsible for the Project are as follows:

   4-1. The Lilongwe Water Board will be the executing agency for the Project (hereinafter referred to as "the Executing Agency"). The Executing Agency shall coordinate with all the relevant authorities to ensure smooth implementation of the Project and ensure that the undertakings for the Project shall be taken care by relevant authorities properly and on time. The organization charts are shown in Annex 2 , and the project implementation structure is shown in Annex 3.

   4-2. The line ministry of the Executing Agency is the Ministry of Agriculture, Irrigation and Water Development. The Ministry of Agriculture, Irrigation and Water Development shall be responsible for supervising the Executing Agency on behalf of the Government of Malawi and facilitation on tax exemption process conducted by the Executing Agency.

5. Contents of the Draft Report

After the explanation of the contents of the Draft Report by the Team, the Malawian side agreed to its contents on the component of Non-Revenue Water Reduction. With respect to the component of Ground Water Development, however, the Malawian side expressed its opinion that further discussions and surveys are required to come up with any conclusive decision regarding the request of procuring a drilling rig for deeper drilling and wider diameter boreholes. The Team took note of it and agreed to convey it to its headquarters in Tokyo. In the meantime, both sides confirmed that the Preparatory Survey on the Project will be completed as scheduled, and that procurement of the equipment for Non-Revenue Water Reduction should be processed for realization according to the Project Implementation Schedule shown in Annex 5.

6. Cost estimate

Both sides confirmed that the cost estimate described in the Annex 4 is provisional and will be examined further by the Government of Japan for its approval.

7. Confidentiality of the cost estimate and technical specifications

Both sides confirmed that the cost estimate and technical specifications in the Draft Report should never be duplicated or disclosed to any third parties until all the contracts under the Project are concluded.

8. Timeline for the project implementation

The Team explained to the Malawian side that the expected timeline for the project implementation is as attached in Annex 5.

9. Expected outcomes and indicators

Both sides agreed that key indicators for expected outcomes are as follows. The Malawian side will be responsible for the achievement of agreed key indicators targeted in year 2022 and shall monitor the progress based on those indicators.

As for the average time required for a pipe repair work, the Executing Agency shall record starting time as well as completion time for every pipe repair work.

As for the total length of pipelines subjected to leakage detection, the Executing Agency shall collect the record on a monthly basis from three zone offices.

[Quantitative indicators]

Indicator	Unit	Baseline value (observed in 2017)	Target value (year 2022) 【three years after the Project completion】
Average time required for a pipe repair work	hour/repair	2.5 (*1)	1.5
Total length of pipelines subjected to leakage detection	km/year	0 (*2)	175

(*1) Median of 15 activity reports (September 10 to October 8, 2017) by the Executing Agency

(*2) Currently, leakage detection is not conducted by the Executing Agency.

[Qualitative indicators]

- Improvement of water supply service by reduction of leakage
- Increase of revenue of the Executing Agency through reduction of Non-Revenue Water
- Less service interruption resulting from the failure of commercial power supply within Southern Zone Office.

10. Undertakings of the Project

Both sides confirmed the undertakings of the Project as described in Annex 6. With regard to exemption of customs duties, internal taxes and other fiscal levies as stipulated in (2) 5 of Annex 6, both sides confirmed that such customs duties, internal taxes and other fiscal levies include VAT, commercial tax, income tax and corporate tax, which shall be clarified in the bid documents by LWB during the implementation stage of the Project.

The Malawian side assured to take the necessary measures and coordination including allocation of the necessary budget which are preconditions of implementation of the Project. It is further agreed that the costs are indicative, i.e. at Outline Design level. More accurate costs will be calculated at the Detailed Design stage.

Both sides also confirmed that the Annex 6 will be used as an attachment of G/A.

11. Monitoring during the implementation

The Project will be monitored by the Executing Agency and reported to JICA by using the form of Project Monitoring Report (PMR) attached as Annex 8. The timing of submission of the PMR is described in Annex 6.

12. Project completion

Both sides confirmed that the project completes when all the facilities constructed and equipment procured by the grant are in operation. The completion of the Project will be reported to JICA promptly, but in any event not later than six months after completion of the Project.

13. Ex-Post Evaluation

JICA will conduct ex-post evaluation after three (3) years from the project completion, in principle, with respect to five evaluation criteria (Relevance, Effectiveness, Efficiency, Impact, Sustainability). The result of the evaluation will be publicized. The Malawian side is required to provide necessary support for the data collection.

14. Schedule of the Study

JICA will finalize the Preparatory Survey Report based on the confirmed items. The report will be sent to the Malawian side around March, 2018.

15. Environmental and Social Considerations

15-1 Environmental Guidelines and Environmental Category

The Team explained that 'JICA Guidelines for Environmental and Social Considerations (April 2010)' (hereinafter referred to as "the Guidelines") is applicable for the Project. The Project is categorized as C because the Project is likely to have minimal adverse impact on the environment under the Guidelines.

16. Other Relevant Issues

16-1. Disclosure of Information

Both sides confirmed that the Preparatory Survey Report from which project cost is excluded will be disclosed to the public after completion of the Preparatory Survey. The comprehensive report including the project cost will be disclosed to the public after all the contracts under the Project are concluded.

16-2. Groundwater Development Component

16-2-1. Preconditions agreed by both sides on July 2017

The Team carefully reviewed and assessed the feasibility of Groundwater Development Component based on the preconditions agreed by both sides in the Minutes of Discussions signed on 20 July, 2017. The five preconditions are shown in below.

1) MAIWD has a concrete plan for groundwater development with 100m or deeper, including some names and number of targeted villages/localities.

2) *An Aquifer(s) has been identified by an existing hydrogeological survey.*
3) *MAIWD has sustainable operation and maintenance system for the targeted drilling rig, such as stable supply chain of spare parts, skilled staffs, and financial resources.*
4) *The targeted villages or communities can operate and maintain developed wells with stable supply chain of spare parts, skilled mechanic, and sufficient financial resources.*
5) *Private companies do not have appropriate sustainable capacity for drilling 100m or deeper in Malawi.*

Finally, the Team judged that development of a more concrete plan for groundwater development on deeper aquifers will be necesarry prior to the procurement of drilling rig.

16-2-2 Exclusion of Groundwater Development Component from the Scope of the Project

Based on the confirmation mentioned in Article 16-2-1, the Team explained and the Malawian side agreed that the Project will not include Groundwater Development Component.

16-2-3 Importance of Groundwater Development

Taking the reservation from Malawian side into account, both sides confirmed the importance to develop a more concrete plan for stretegic and effective water resource development including groundwater development in Malawi.

If MAIWD try to develop more concrete plan for groundwater development thorough sorting out and integrating necessary data, JICA would support the MAIWD's activity as much as possible through Water Resource Advisor in MAIWD dispatched by JICA.

16-3. Title of Grant Aid Project

In consequence of the exclusion of Groundwater Development Component in the preceding Article 16-2-2, both sides agreed to make the title of subsequent Grant Aid Project "the Project for Improvement of Non-Revenue Water Reduction Equipment in Lilongwe", taking nature of the Project into account, though the title of the Preparatory Survey is "the Preparatory Survey for the Project for Improvement of Ground Water Development and Non-Revenue Water Reduction" as mentioned in Article 2.

16-4. Technical Assistance ("Soft Component" of the Project)

Both sides confirmed that technical assistance is not included in the Project because LWB staffs already have basic skill and knowledge to utilize, operate and maintain

the equipment procured under the Project, otherwise will acquire them through initial operational guidance by manufacturer in a relatively short period.

16-5. Tax Exemption

16-5-1. General

The Malawian side agreed to take necessary measures to exempt taxes, including Value Added Tax (hereinafter referred to as "VAT"), custom duty, income tax, and any other taxes which are to be arisen from the Project activities in Malawi.

16-5-2. Procedure of Tax Exemption (VAT and Custom Duty)

LWB shall submit letter to the Malawi Revenue Authority (MRA) applying for the "Free Status" of Value Added Tax (VAT) and Customs Duty for the Project through principal secretary of MAIWD. The letter should be accompanied by the G/A, a copy of the contracts with the contractors and Bill of Quantities showing the list of procured equipment. Malawian sides agreed to take necessary procedures in timely manner since the process for Custom Duty would take approximately a month for approval.

16-6. Storage Space at LWB Headquarters

LWB agreed to build sheltered storage space of approximately twenty (20) square meters at its Headquarters to store the materials to be procured under the Project prior to the delivery of the equipment.

16-7. Installation of Emergency Power Generator at Mwenda Booster Pump Station

LWB agreed to make foundation work for installation of emergency power generator at Mwenda Booster Pump Station (the South Zone Office), including construction of reinforced concrete foundation of approximately forty-five (45) square meters as well as necessary wiring work, at its own expense.

16-8. Security Management

The Malawian side agreed to build information collection and emergency contact system among the Executing Agency, the consultant and the contractor/supplier under the Project for security management.

16-9. Public Relations as undertakings of the Malawian Side

Both sides understand the value and importance of public relations (hereinafter referred to as "PR") of the Project. The Malawian side agreed to conduct PR activities in Malawi such as handing over ceremony.

16-10. Technical Cooperation "the Project for Strengthening the Capacity of Non-Revenue Water Reduction for Lilongwe Water Board"

"The Project for Strengthening the Capacity of Non-Revenue Water Reduction for Lilongwe Water Board" would be commenced in the first half of Japanese Fiscal Year 2018 with the target to strengthen LWB's capacity for Non-Revenue Water reduction management.

Therefore, both sides confirmed that both projects should be implemented in synergic manner and equipment procured under the Project shall be utilized for pilot activities of the technical cooperation.

16-11. Distribution of Equipment within LWB

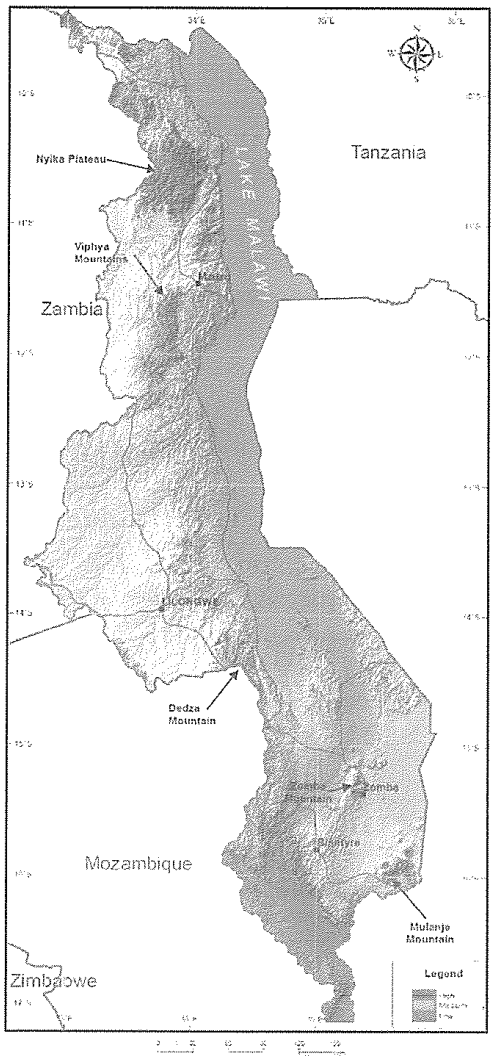
Both sides confirmed all the equipment except for an emergency power generator to be delivered and installed at Mwenda Booster Pump Station will be delivered by Japanese side to LWB headquarters and inspected there.

Moreover, both sides confirmed the importance to utilize the equipment immediately in appropriate manner. Therefore, LWB agreed to distribute the equipment to respective locations promptly after handing over with reference to Annex 7, at its own expense, since LWB is responsible for placement of equipment.

Annex 1 Project Site
Annex 2 Organization Chart
Annex 3 Project Implementation Structure
Annex 4 Estimated Project Cost (confidential)
Annex 5 Project Implementation Schedule
Annex 6 Major Undertakings to be taken by the Government of Malawi
Annex 7 Tentative Composition of Equipment
Annex 8 Project Monitoring Report (template)

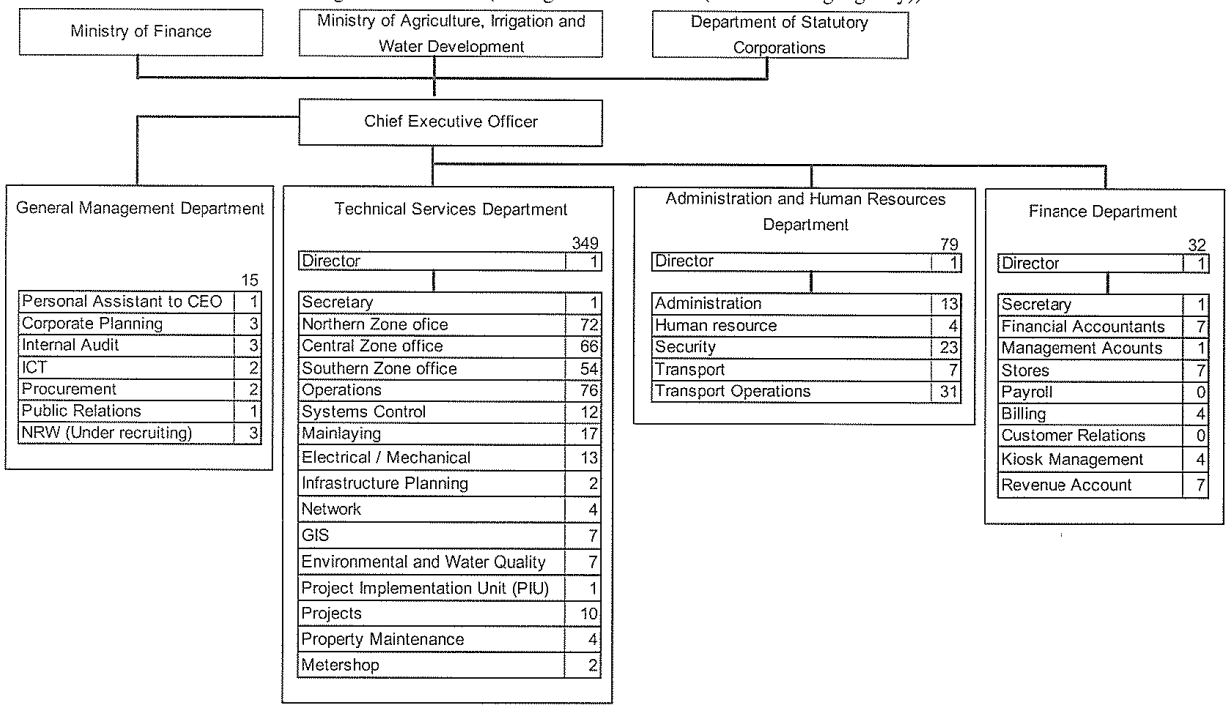
Annex 1

Project Site



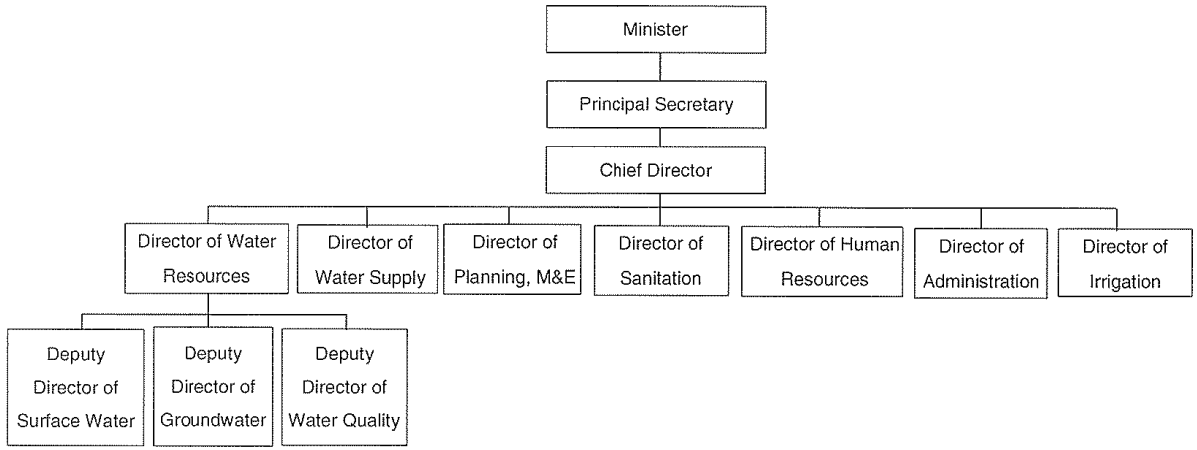
Annex 2-a

Organization Chart (Lilongwe Water Board (the Executing Agency))



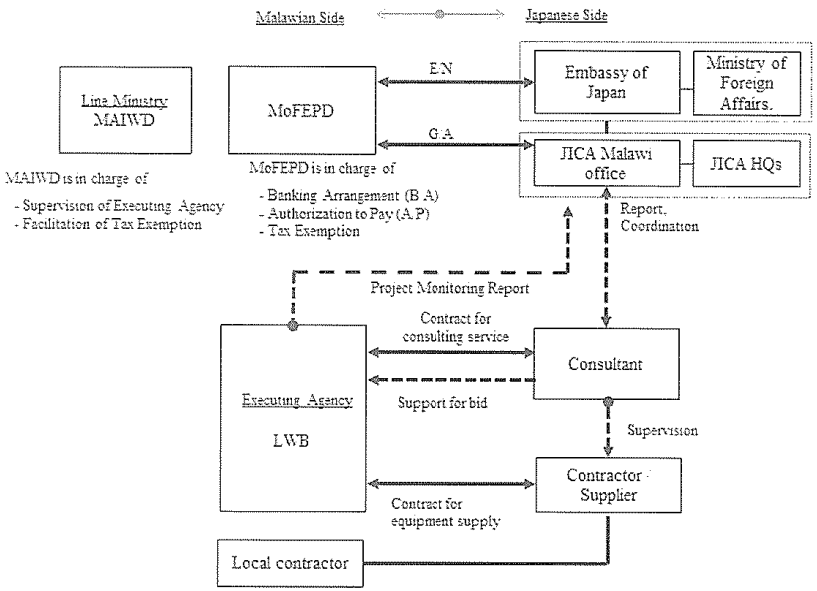
Annex 2-b

Organization Chart (Ministry of Agriculture, Irrigation and Water Development (the Line Ministry))



Annex 3

Project Implementation Structure



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Annex 4

Estimated Project Costs

The total project cost required for the components to be covered by Japanese side is estimated at approx. [redacted] million Japanese yen. It is, however, noted that this does not indicate the amount of grant which will be shown in the Exchange of Note.

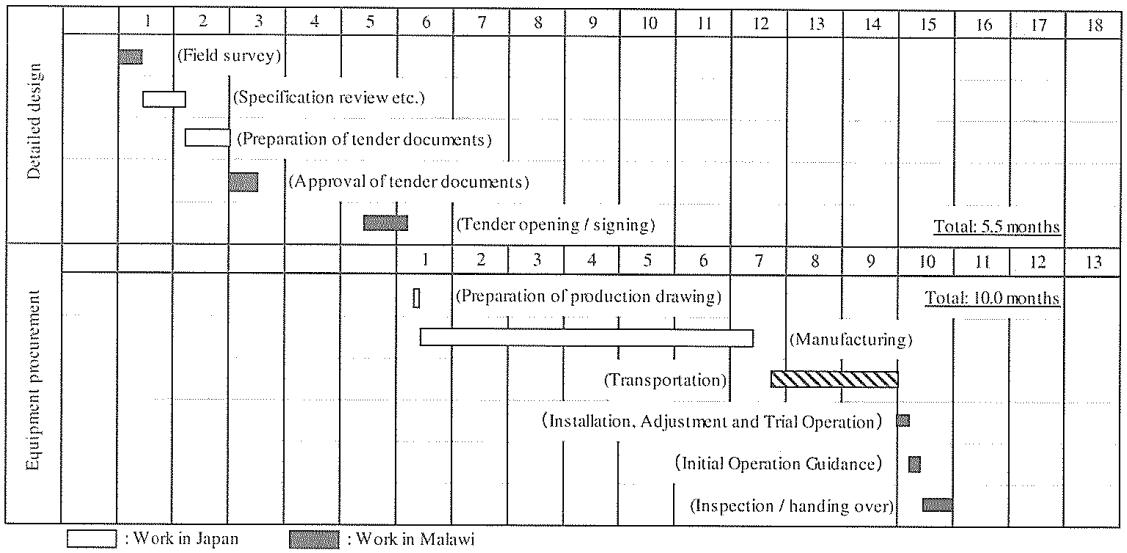
Total Project Cost: Approx. [redacted] million Japanese yen

Items	Project Costs (Mil. JPY)
Procurement Costs of Equipment	[redacted]
Engineering Fees for Detailed Design, Assistance in Tendering and Construction Supervision	[redacted]
	[redacted]

[redacted]

Annex 5

Project Implementation Schedule



Annex 6

Major Undertakings to be taken by the Government of Malawi

1. Specific obligations of the Government of Malawi which will not be funded with the Grant

(1) Before the Tender

NO	Items	Deadline	In charge	Estimated Cost	Ref.
1	To open bank account (B/A)	within 1 month after the signing of the G/A	MoFEPD / LWB		
2	To issue A/P to a bank in Japan (the Agent Bank) for the payment to the consultant	within 1 month after the signing of the contract	MoFEPD / LWB		
3	To bear the following commissions to a bank in Japan for the banking services based upon the B/A				
	1) Advising commission of A/P	within 1 month after the signing of the contract(s)	MoFEPD / LWB		
	2) Payment commission for A/P	every payment	MoFEPD / LWB		
4	To secure storage space for equipment in LWB Headquarters and three reginal offices	before notice of the bidding document	LWB		
5	To secure space for installation of Back Up Generator in Mwenda Booster Pump Station	before notice of the bidding document	LWB		
6	To submit Project Monitoring Report (with the result of Detail Design)	before preparation of bidding documents	LWB		

(B/A: Banking Arrangement, A/P: Authorization to pay, MoFEPD: Ministry of Finance, Economic Planning and Development,

LWB: Lilongwe Water Board)

(2) During the Project Implementation

NO	Items	Deadline	In charge	Estimated Cost	Ref.
1	To issue A/P to a bank in Japan (the Agent Bank) for the payment to the Supplier(s)	within 1 month after the signing of the contract(s)	MoFEPD / LWB	0.2 million JPY	
2	To bear the following commissions to a bank in Japan for the banking services based upon the B/A				
	1) Advising commission of A/P	within 1 month after the signing of the contract(s)	MoFEPD / LWB		
	2) Payment commission for A/P	every payment	MoFEPD / LWB		
3	To ensure prompt customs clearance and to assist the Supplier(s) with internal transportation in recipient country	during the Project	MoFEPD / MAIWD / LWB		
4	To accord Japanese nationals and/or physical persons of third countries whose services may be required in connection with the supply of the products and the services such facilities as may be necessary for their entry into the country of the Recipient and stay therein for the performance of their work	during the Project	MoFEPD / LWB		
5	To ensure that customs duties, internal taxes and other fiscal levies which may be imposed in the country of the Recipient with respect to the purchase of the products and/or the services be exempted	during the Project	MoFEPD / MAIWD / LWB		
6	To bear all the expenses, other than those covered by the Grant, necessary for the implementation of the Project	during the Project	LWB		
7	1) To submit Project Monitoring Report after each work under the contract(s) such as shipping, hand over, installation and operational training	within one month after completion of each work	LWB		
	2) To submit Project Monitoring Report (final)	within one month after signing of Certificate of Completion for the works under the contract(s)	LWB		

8	To submit a report concerning completion of the Project	within six months after completion of the Project	LWB		
9	To build additional storage for materials in LWB headquarters	before arrival of equipment	LWB	1.2 million JPY	
10	1) Foundation work to install Back Up Generator in Mwenda Booster Pump Station	before arrival of equipment	LWB	0.7 million JPY	
	2) Wiring work for Back Up Generator in Mwenda Booster Pump Station	after arrival of equipment	LWB		
11	To distribute equipment from LWB headquarters to each zone offices for actual use	after handing over	LWB		
12	To attend inspection of equipment	At the time of inspection	LWB		

(MAIWD: Ministry of Agriculture, Irrigation and Water Development)

(3) After the Project

NO	Items	Deadline	In charge	Estimated Cost	Ref.
1	To maintain and use properly and effectively the equipment provided under the Grant Aid 1) Allocation of maintenance cost 2) Operation and maintenance structure 3) Routine check/Periodic inspection	After completion of the Project	LWB	129 million MWK / year	
2	To record starting time as well as completion time for every pipe repair work	After completion of the Project	LWB		
	To record length of pipelines subjected to leakage detection	After completion of the Project	LWB		

*This page is closed due to the confidentially.

2. Other obligations of the Government of Malawi funded with the Grant

NO	Items	Deadline	Amount (Million Japanese Yen)*
1	1) To conduct the following transportation a) Marin transportation of the products from Japan to the recipient country b) Internal transportation from the port of disembarkation to the project site	Project Completion	
	2) To provide equipment with installation and commissioning		
2	To implement detailed design, bidding support and procurement supervision (Consulting Service)		
	Total		[redacted]

*The Amount is provisional. This is subject to the approval of the Government of Japan.

Annex 7

Tentative Composition of Equipment

Component	Item	Quantity	Procurement breakdown
Equipment for pipe installation	Pipe Drilling Tools	11 Units	North・Centralx4 Units、Southx3 Units
	Pipe Threading Tool	12 Units	North・Central・Southx4 Units
	Pipe Cutter	6 Units	North・Central・Southx2 Units
	Lifting Tools		
	◎Chain Hoist	12 Units	North・Central・Southx4 Units
	◎Lever Hoist	12 Units	North・Central・Southx4 Units
	Small Generator	11 Units	North・Centralx4 Units、Southx3 Units
	Electric Welding Machine	3 Units	North・Central・Southx1 Unit
	Tools	12 Sets	North・Central・Southx4 Sets
	Compactor		
	◎Plate Compactor	12 Units	North・Central・Southx4 Units
	◎Hand Compactor	12 Units	North・Central・Southx4 Units
	Small Excavator	2 Units	North・Centralx1 Unit
	Truck with Crane	3 Units	North・Central・Southx1 Unit
	Engine Pump	6 Sets	North・Central・Southx2 Sets
	Lighting Gear		
	◎Generator Integrated Lighting Gear	3 Units	North・Central・Southx1 Unit
	◎Lighting Gear	5 Units	North・Centralx2 Units、Southx1 Unit
	Pipe Repair Clamp and Dresser Joint		
	◎Pipe Repair Clamp	4,179 Pieces	ND63x1944、ND110x1446、ND160x789
	◎Dresser Joint	3,345 Pieces	ND63x1557、ND110x1158、ND160x630
	Water Pressure Tester	3 Sets	North・Central・Southx1 Set
	Transporter Truck for Small Excavator	3 Units	North・Central・Southx1 Unit
Leak management	Leak Detection Tool		
	◎Correlation Formula	2 Units	North・Centralx1 Unit

equipment	◎Sound Hearing	5 Units	North・Central×1 Unit、South×3 Units
	Pressure Meter With Data Logger	4 Units	North・Central×2 Units
	Leak Sound Detection Bar ◎Analog type ◎Digital type	 11 Units 11 Units	 North・Central×4 Units、South×3 Units North・Central×4 Units、South×3 Units
	Pipeline Detector	2 Units	North・Central×1 Unit
Management and inspection equipment	Accuracy Tester of Water Meter	6 Units	North・Central・South×2 Units
	Pressure Gauge for Water Faucet	20 Pieces	North・Central×10 Pieces
	Motorcycle	6 Units	North・Central・South×2 Units
Equipment for back up generator	Back Up Generator	1 Unit	South×1 Unit

Project Monitoring Report
on
Project Name
Grant Agreement No. XXXXXXX

20XX, Month

Organizational Information

Signer of the G/A (Recipient)	Person in Charge	(Designation)
	Contacts	Address: Phone/FAX: Email:
Executing Agency	Person in Charge	(Designation)
	Contacts	Address: Phone/FAX: Email:
Line Ministry	Person in Charge	(Designation)
	Contacts	Address: Phone/FAX: Email:

General Information:

Project Title	
E/N	Signed date: Duration:
G/A	Signed date: Duration:
Source of Finance	Government of Japan: Not exceeding JPY _____ mil. Government of (_____): _____

Draft

1: Project Description

1-1 Project Objective

1-2 Project Rationale

- Higher-level objectives to which the project contributes (national/regional/sectoral policies and strategies)
- Situation of the target groups to which the project addresses

1-3 Indicators for measurement of "Effectiveness"

Quantitative indicators to measure the attainment of project objectives		
Indicators	Original (Yr)	Target (Yr)
Qualitative indicators to measure the attainment of project objectives		

2: Details of the Project

2-1 Location

Components	Original *(proposed in the outline design)*	Actual
1.		

2-2 Scope of the work

Components	Original* *(proposed in the outline design)*	Actual*
1.		

Reasons for modification of scope (if any).

(PMR)

2-3 Implementation Schedule

Items	Original		Actual
	(proposed in the outline design)	*(at the time of signing the Grant Agreement)*	

Reasons for any changes of the schedule, and their effects on the project (if any)

2-4 Obligations by the Recipient

2-4-1 Progress of Specific Obligations

See Attachment 2.

2-4-2 Activities

See Attachment 3.

2-4-3 Report on RD

See Attachment 11.

2-5 Project Cost

2-5-1 Cost borne by the Grant(Confidential until the Bidding)

Components			Cost (Million Yen)	
	Original *(proposed in the outline design)*	Actual *(in case of any modification)*	Original[1),2)] *(proposed in the outline design)*	Actual
	1.			
Total				

Note: 1) Date of estimation:
2) Exchange rate: 1 US Dollar = Yen

2-5-2 Cost borne by the Recipient

Components			Cost (1,000 Taka)	
	Original *(proposed in the outline design)*	Actual *(in case of any modification)*	Original[1),2)] *(proposed in the outline design)*	Actual
	1.			

Note: 1) Date of estimation:
2) Exchange rate: 1 US Dollar =

Reasons for the remarkable gaps between the original and actual cost, and the countermeasures (if any)

(PMR)

2-6 Executing Agency

- Organization's role, financial position, capacity, cost recovery etc,
- Organization Chart including the unit in charge of the implementation and number of employees.

Original *(at the time of outline design)* name: role: financial situation: institutional and organizational arrangement (organogram): human resources (number and ability of staff):
Actual *(PMR)*

2-7 **Environmental and Social Impacts**

- The results of environmental monitoring based on Attachment 5 (in accordance with Schedule 4 of the Grant Agreement).
- The results of social monitoring based on in Attachment 5 (in accordance with Schedule 4 of the Grant Agreement).
- Disclosed information related to results of environmental and social monitoring to local stakeholders (whenever applicable).

3: Operation and Maintenance (O&M)

3-1 Physical Arrangement

- Plan for O&M (number and skills of the staff in the responsible division or section, availability of manuals and guidelines, availability of spareparts, etc.)

Original *(at the time of outline design)*
Actual *(PMR)*

3-2 Budgetary Arrangement

- Required O&M cost and actual budget allocation for O&M

Original *(at the time of outline design)*

Actual *(PMR)*

4: Potential Risks and Mitigation Measures

- Potential risks which may affect the project implementation, attainment of objectives, sustainability
- Mitigation measures corresponding to the potential risks

Assessment of Potential Risks *(at the time of outline design)*

Potential Risks	Assessment
1. (Description of Risk)	Probability: High/Moderate/Low
	Impact: High/Moderate/Low
	Analysis of Probability and Impact:
	Mitigation Measures:
	Action required during the implementation stage:
	Contingency Plan (if applicable):
2. (Description of Risk)	Probability: High/Moderate/Low
	Impact: High/Moderate/Low
	Analysis of Probability and Impact:
	Mitigation Measures:
	Action required during the implementation stage:
	Contingency Plan (if applicable):
3. (Description of Risk)	Probability: High/Moderate/Low
	Impact: High/Moderate/Low
	Analysis of Probability and Impact:
	Mitigation Measures:
	Action required during the implementation stage:

	Contingency Plan (if applicable):
Actual Situation and Countermeasures	
(PMR)	

5: Evaluation and Monitoring Plan (after the work completion)

5-1 Overall evaluation

Please describe your overall evaluation on the project.

5-2 Lessons Learnt and Recommendations

Please raise any lessons learned from the project experience, which might be valuable for the future assistance or similar type of projects, as well as any recommendations, which might be beneficial for better realization of the project effect, impact and assurance of sustainability.

5-3 Monitoring Plan of the Indicators for Post-Evaluation

Please describe monitoring methods, section(s)/department(s) in charge of monitoring, frequency, the term to monitor the indicators stipulated in 1-3.

Attachment

1. Project Location Map
2. Specific obligations of the Recipient which will not be funded with the Grant
3. Monthly Report submitted by the Consultant

Appendix - Photocopy of Contractor's Progress Report (if any)
- Consultant Member List
- Contractor's Main Staff List

4. Check list for the Contract (including Record of Amendment of the Contract/Agreement and Schedule of Payment)
5. Environmental Monitoring Form / Social Monitoring Form
6. Monitoring sheet on price of specified materials (Quarterly)
7. Report on Proportion of Procurement (Recipient Country, Japan and Third Countries) (PMR (final)only)
8. Pictures (by JPEG style by CD-R) (PMR (final)only)
9. Equipment List (PMR (final)only)
10. Drawing (PMR (final)only)
11. Report on RD (After project)

Attachment 6

Monitoring sheet on price of specified materials

1. Initial Conditions (Confirmed)

	Items of Specified Materials	Initial Volume A	Initial Unit Price (¥) B	Initial total Price C=A×B	1% of Contract Price D	Condition of payment	
						Price (Decreased) E=C−D	Price (Increased) F=C+D
1	Item 1	●●t	●	●	●	●	●
2	Item 2	●●t	●	●	●		
3	Item 3						
4	Item 4						
5	Item 5						

2. Monitoring of the Unit Price of Specified Materials

(1) Method of Monitoring : ●●

(2) Result of the Monitoring Survey on Unit Price for each specified materials

	Items of Specified Materials	1st ●month, 2015	2nd ●month, 2015	3rd ●month, 2015	4th	5th	6th
1	Item 1						
2	Item 2						
3	Item 3						
4	Item 4						
5	Item 5						

(3) Summary of Discussion with Contractor (if necessary)

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Attachment 7

Report on Proportion of Procurement (Recipient Country, Japan and Third Countries)
(Actual Expenditure by Construction and Equipment each)

		Domestic Procurement (Recipient Country) A	Foreign Procurement (Japan) B	Foreign Procurement (Third Countries) C	Total D
Construction Cost		(A/D%)	(B/D%)	(C/D%)	
	Direct Construction Cost	(A/D%)	(B/D%)	(C/D%)	
	others	(A/D%)	(B/D%)	(C/D%)	
Equipment Cost		(A/D%)	(B/D%)	(C/D%)	
Design and Supervision Cost		(A/D%)	(B/D%)	(C/D%)	
Total		(A/D%)	(B/D%)	(C/D%)	

5. Other Relevant Data

Project Monitoring Report

Tax Exemption Information Sheet

Collected Data List

Recommendations for Groundwater Development

Project Monitoring Report

Project Monitoring Report
on
The Project for the Improvement of Equipment for Non-Revenue Water Reduction in Lilongwe
Grant Agreement No. XXXXXXX

20XX, Month

Organizational Information

Signer of the G/A (Recipient)	**Ministry of Finance, Economic Planning and Development** Person in Charge (Designation) Contacts Address: Phone/FAX: Email:
Executing Agency	**Lilongwe water board** Person in Charge (Designation) Mr.Stevie Kazembe Contacts Address: Madzi House, Likuni Road, P.O. Box 96, Lilngwe Malawi Phone/FAX: 265 1 750 366 Email: Madzi@lwb.mw
Line Ministry	**Ministry of Agriculture, Irrigation and Water Development** Person in Charge (Designation) Contacts Address: Tikwere House, City Centre, Private Bag 390, Capital City, Lilongwe 3, Malawi. Phone/FAX: +265 1 770 344 Email: secretary@irriwater.org

General Information:

Project Title	The Project for the Improvement of Equipment for Non-Revenue Water Reduction in Lilongwe
E/N	Signed date: Duration:
G/A	Signed date: Duration:
Source of Finance	Government of Japan: Not exceeding JPY _____ mil. Government of (_____): _____

1: Project Description

1-1 Project Objective

The Government of Malawi placed a high priority on water resource development in line with the Malawi Growth and Development Strategy II to improve the water supply situation in areas. In Lilongwe City, Lilongwe Water Board is working on reducing Non-Revenue Water (hereinafter referred to as "NRW") rate to 28% by 2020. Nevertheless, the results of the effort are limited. The Project for the Improvement of Equipment for Non-Revenue Water Reduction in Lilongwe (hereinafter referred to as "the Project") aims to contribute to the stable water supply in Lilongwe city. The Project will enhance the water-use efficiency in the city through the maintenance of equipment for NRW reduction.

1-2 Project Rationale

- Higher-level objectives to which the project contributes (national/regional/sectoral policies and strategies)
- Situation of the target groups to which the project addresses

Improvement of water supply in Lilongwe city is prioritized in "National Water Resource Master Plan" formulated through "Project for National Water Resources Master Plan Resources in the Republic of Malawi" (2012-2014). In particular, NRW reduction is the highest priority area to improve water use efficiency of existing water resources. Moreover, Lilongwe Water Board Strategic Plan 2015-2020 sets the goal to reduce NRW rate (36%) in 2015 to 28% in 2020. Hence, the Project is in line with these development plans in Malawi.
In addition, "Country Assistance Policy for the Republic of Malawi" (April 2012) stated by the Government of Japan addresses "Improvement of basic social services" as priority areas and "Safe and Stable Water Supply Programme" is tackling improvement of stable water supply through rehabilitation of facilities and enhancement of operation and maintenance system. On that account, the Project corresponds to development cooperation policy of the Government of Japan to Malawi. Indeed, LWB is the direct beneficiary of the Project; however citizens in Lilongwe including poor group will also be benefited by the Project since universal and equal access to safe and affordable drinking water to them will be realized thorough improvement of NRW management efficiency, reduction of NRW and improvement of the water supply service in Lilongwe.
Therefore, implementation of the Project is in line with Japanese cooperation policies and analysis as well as development plans and policies in Malawi. Furthermore, it contributes to improvement of water use efficiency and water supply service through maintaining equipment for NRW reduction and it promotes Sustainable Development Goals 6 ("Ensure availability and sustainable management of water and sanitation for all "). Therefore, it is highly relevant to support the implementation of the Project.

1-3 Indicators for measurement of "Effectiveness"

Quantitative indicators to measure the attainment of project objectives

Indicators	Original (Yr 2017)	Target (Yr 2022)
Average period of repairing pipes (hour/year)	2.5	1.5
Leakage detection distance (km/year)	0	175

Qualitative indicators to measure the attainment of project objectives

- Improvement of LWB's management (by Reduction of overtime through improving work efficiency and by increase of revenue due to increased revenue earning water)
- Improvement of satisfaction of LWB's customer (by Improvement of reliability of LWB's work such as prompt pipe repairs)
- Water resource conservation in Lilongwe River basin (by Reduction of excessive water intake from Lilongwe River due to leakage reduction)

2: Details of the Project

2-1 Location

Components	Original *(proposed in the outline design)*	Actual
1. The site of the Project is within LWB Zone Offices and the LWB headquarter.	Refer to Attachment 1	

2-2 Scope of the work

Components	Original* *(proposed in the outline design)*		Actual*
1. Equipment for pipe installation	Pipe Drilling Tools*	11 Units	
	Pipe Threading Tool	12 Units	
	Pipe Cutter	6 Units	
	Lifting Tools		
	●Chain Hoist	12 Units	
	●Lever Hoist	12 Units	
	Small Generator *	11 Units	
	Electric Welding Machine	3 Units	
	Tools	12 Sets	
	Compactor		
	●Plate Compactor	12 Units	
	●Hand Compactor	12 Units	
	Small Excavator *	2 Units	
	Truck with Crane	3 Units	
	Engine Pump	6 Sets	
	Lighting Gear		
	●Generator Integrated Lighting Gear	3 Units	
	●Lighting Gear *	5 Units	
	Pipe Repair Clamp and Dresser Joint		
	●Pipe Repair Clamp	4,179 Pieces	
	●Dresser Joint	3,345 Pieces	
	Water Pressure Tester	3 Sets	
	Transporter Truck for Small Excavator	3 Units	
2. Leak management equipment	Leak Detection Tool		
	●Correlation Formula *	2 Units	
	●Sound Hearing *	5 Units	
	Pressure Meter With Data Logger *	4 Units	
	Leak Sound Detection Bar		
	●Analog type *	11 Units	
	●Digital type *	11 Units	
	Pipeline Detector *	2 Units	
3. Management and	Accuracy Tester of Water Meter	6 Units	

Components	Original* (proposed in the outline design)		Actual*
inspection equipment	Pressure Gauge for Water Faucet *	20 Pieces	
	Motorcycle	6 Units	
4. Equipment for backup generator	Backup Generator	1 Unit	
Consulting service	Detailed design service, the supervisory service in the equipment procurement and preparing tender documents		

Reasons for modification of scope (if any).

(PMR)

2-3 Implementation Schedule

Items	Original		Actual
	(proposed in the outline design)	*(at the time of signing the Grant Agreement)*	
Cabinet Approval E/N	2/2018		
G/A	3/2018		
Announcement of tender	5/2018		
Bid	7/2018		
Product of equipment	8/2018~5/2019		
Adjustment, trial operation, start-up and operation training	5/2019		
Defect Liability Period	6/2020		
Project Completion			

Reasons for any changes of the schedule, and their effects on the project (if any)

2-4 Obligations by the Recipient

2-4-1 Progress of Specific Obligations

See Attachment 2.

2-4-2 Activities

See Attachment 3.

2-5 Project Cost

2-5-1 Cost borne by the Grant (<u>Confidential until the Bidding</u>)

Components			Cost (Million Yen)	
	Original *(proposed in the outline design)*	Actual *(in case of any modification)*	Original[1),2)] *(proposed in the outline design)*	Actual
	Equipment			
	Detail design, Procurement Supervision			
Total				

Note: 1) Date of estimation:
2) Exchange rate:

2-5-2 Cost borne by the Recipient

Components			Cost (USD)	
	Original *(proposed in the outline design)*	Actual *(in case of any modification)*	Original[1),2)] *(proposed in the outline design)*	Actual
	Issue of A/P		1,602.9	
	Secure of equipment storage location		10,919.1	
	Secure of install place for Back Up Generator		6,195.2	
			18,717.2	

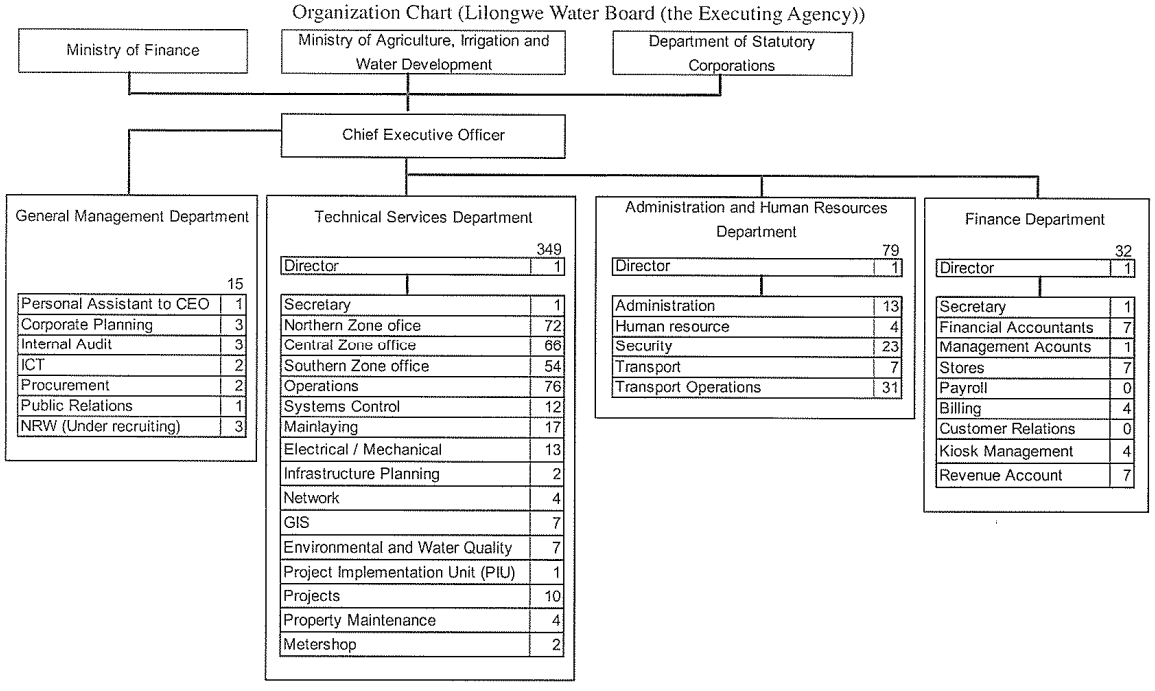
Note: 1) Date of estimation: August, 2017
2) Exchange rate: 1 US Dollar =112.83 Yen, 1 MKW = 0.156 YEN

Reasons for the remarkable gaps between the original and actual cost, and the countermeasures (if any)

(PMR)

2-6 Executing Agency

Organization Chart (Lilongwe Water Board (the Executing Agency))



- Organization's role, financial position, capacity, cost recovery etc.
- Organization Chart including the unit in charge of the implementation and number of employees.

Original *(at the time of outline design)* Name: Lilongwe Water Board Role: LWB is responsible for water supply service in Lilongwe city. Financial situation: According to the Profit and Loss Statement of LWB, financial situation of LWB is continuously improving. Institutional and organizational arrangement (organogram): Human resources (number and ability of staff): around 500 staffs
Actual *(PMR)*

2-7 Environmental and Social Impacts

- The results of environmental monitoring based on Attachment 5 (in accordance with Schedule 4 of the Grant Agreement).
- The results of social monitoring based on in Attachment 5 (in accordance with Schedule 4 of the Grant Agreement).
- Disclosed information related to results of environmental and social monitoring to local stakeholders (whenever applicable).

3: Operation and Maintenance (O&M)

3-1 Physical Arrangement

- Plan for O&M (number and skills of the staff in the responsible division or section, availability of manuals and guidelines, availability of spare parts, etc.)

Original *(at the time of outline design)* Arrangement of new personnel is not required to operate and maintain the equipment to be procured under the Project since the equipment will be utilized for daily and regular work (pipe repair work) mainly at LWB Zone Offices. Most of the equipment such as excavators, tools, hangers, water pressure gauge, etc., does not require operating costs (fuel cost). On the other hand, operating costs are required for the equipment such as small excavators, small power generator, trucks with cranes, transporter truck for small excavator, motor bikes and back-up generators. In addition, LWB has to prepare consumable goods, such as cutter blades, oil and air filters, for maintenance of the equipment except pipe repair clamps, joints and tools.
Actual *(PMR)*

3-2 Budgetary Arrangement

- Required O&M cost and actual budget allocation for O&M

Original *(at the time of outline design)* Regarding operation and maintenance expenses after completion of the Project, the personnel expenses are estimated to be 7.5 million MWK per year (about 1.2 million yen), and the operation cost is estimated at 121.6 million MWK per year (about 19.0 million yen).
Actual *(PMR)*

4: Potential Risks and Mitigation Measures

- Potential risks which may affect the project implementation, attainment of objectives, sustainability
- Mitigation measures corresponding to the potential risks

Assessment of Potential Risks (*at the time of outline design)*

Potential Risks	Assessment
1.	Probability:
	Impact:
	Analysis of Probability and Impact:
	Mitigation Measures:
	Action required during the implementation stage:
	Contingency Plan (if applicable):
Actual Situation and Countermeasures	
(PMR)	

5: Evaluation and Monitoring Plan (after the work completion)

5-1 Overall evaluation

Please describe your overall evaluation on the project.

5-2 Lessons Learnt and Recommendations

Please raise any lessons learned from the project experience, which might be valuable for the future assistance or similar type of projects, as well as any recommendations, which might be beneficial for better realization of the project effect, impact and assurance of sustainability.

5-3 Monitoring Plan of the Indicators for Post-Evaluation

Please describe monitoring methods, section(s)/department(s) in charge of monitoring, frequency, the term to monitor the indicators stipulated in 1-3.

Attachment

1. Project Location Map
2. Specific obligations of the Recipient which will not be funded with the Grant
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9. Equipment List (PMR (final)only)
10. Drawing (PMR (final)only)
11. Report on RD (After project)

Attachment 6

Monitoring sheet on price of specified materials

1. Initial Conditions (Confirmed)

	Items of Specified Materials	Initial Volume A	Initial Unit Price (¥) B	Initial total Price C=A×B	1% of Contract Price D	Condition of payment	
						Price (Decreased) E=C－D	Price (Increased) F=C＋D
1	Item 1	●●t	●	●	●	●	●
2	Item 2	●●t	●	●	●		
3	Item 3						
4	Item 4						
5	Item 5						

2. Monitoring of the Unit Price of Specified Materials

(1) Method of Monitoring：●●

(2) Result of the Monitoring Survey on Unit Price for each specified materials

	Items of Specified Materials	1st ●month, 2015	2nd ●month, 2015	3rd ●month, 2015	4th	5th	6th
1	Item 1						
2	Item 2						
3	Item 3						
4	Item 4						
5	Item 5						

(3) Summary of Discussion with Contractor (if necessary)

-
-
-

Report on Proportion of Procurement (Recipient Country, Japan and Third Countries)
（Actual Expenditure by Construction and Equipment each）

		Domestic Procurement （Recipient Country） A	Foreign Procurement （Japan） B	Foreign Procurement （Third Countries） C	Total D
Construction Cost		（A/D%）	（B/D%）	（C/D%）	
	Direct Construction Cost	（A/D%）	（B/D%）	（C/D%）	
	others	（A/D%）	（B/D%）	（C/D%）	
Equipment Cost		（A/D%）	（B/D%）	（C/D%）	
Design and Supervision Cost		（A/D%）	（B/D%）	（C/D%）	
Total		（A/D%）	（B/D%）	（C/D%）	

Report on Proportion of Procurement (Recipient Country, Japan and Third Countries)
（Actual Expenditure by Construction and Equipment each）

	Domestic Procurement （Recipient Country） A	Foreign Procurement （Japan） B	Foreign Procurement （Third Countries） C	Total D
Construction Cost	（A/D%）	（B/D%）	（C/D%）	
Direct Construction Cost	（A/D%）	（B/D%）	（C/D%）	
others	（A/D%）	（B/D%）	（C/D%）	
Equipment Cost	（A/D%）	（B/D%）	（C/D%）	
Design and Supervision Cost	（A/D%）	（B/D%）	（C/D%）	
Total	（A/D%）	（B/D%）	（C/D%）	

Tax Exemption Information Sheet

Tax Exemption Procedure in Malawi

(1) Fiscal levies and taxes with respect to the corporate income (Corporate tax)

Name	Corporate Tax
Taxable Object	Locally incorporated companies, branches of foreign companies and non-residents are subject to corporate income tax on their income deemed to be from a source in Malawi. Locally incorporated company is a company incorporated in Malawi; branches of foreign company is a company with a permanent establishment (P.E.); and non-resident is a company or individual without a P.E. P.E. is an office or other fixed place of business through business activity is carried on, and is operated in Malawi for an aggregate of 183 or more days in the year of assessment. Companies and individuals with P.E. are considered to be resident for tax purposes, while they are considered to be non-resident without P.E. Residents shall register for tax with MRA and obtain Tax Payer Identification Number (TPIN).
Tax Rate	Locally incorporated companies are subject to corporate income tax at a rate of 30% of net income, while branches of foreign companies are at a rate of 35%. A final tax at a rate of 15% is imposed on non-resident companies and individuals.
Basis Laws	The Taxation Act, Part V, VIIA and Eleventh Schedule
Tax Exemption Procedure, Application Authority, Required Time	【Tax Exemption is available】 Corporate tax shall be exempted for Japanese contractors (payers) for the Project, while it is not exempted for local subcontractors (recipients of the payment). An executing agency (Ministry and Agency) shall prepare and submit a letter to Malawi Revenue Authority (MRA) to apply for tax exemption in advance. It takes approximately 2 or 3 weeks for MRA to approve the letter from application.
Remarks	Malawi applies “Withholding Tax (WHT)” which is an advance payment of income tax that is deducted from specified payments shown in the table below. As seen in the table, WHT has defined tax rates and it is withheld by the payer on behalf of the recipient of the payment and it is remitted to MRA.

	<table><tr><th colspan="2">Withholding Tax Rates</th></tr><tr><td>●Royalties ●Comission ●Public Entertainment ●Bank Interest in Excess of 10,000 MWK ●Over 15,000 MWK for Casual Labour ●Payment for Services</td><td>20%</td></tr><tr><td>●Rent</td><td>15%</td></tr><tr><td>●Carriage and Haulage ● Fees</td><td>10%</td></tr><tr><td>●Contractors/Sub-contractors</td><td>4%</td></tr><tr><td>●Any Supplies to Traders and Instituitions (Food and Other stuff) ●Tobacco Sales</td><td>3%</td></tr></table> Source: 14th Schedule of Taxation Act Recipients of the payments, with Tax Payer Index Number (TPIN), treat the WHT as a corporate tax. The payer shall deduct the WHT from a payment and remit the tax within 14 days from the end of the month during the deduction is made. Recipients of the payments, without TPIN (Registration is not necessary if an annual turnover is less than 10million MWK), treat the tax as a WHT. If the payer do not have TPIN, the payer is allowed not to deduct the tax and make a full payment to the recipient, and the recipient remits the tax to MRA. If neither the payer nor the recipient have TPIN, WHT will not be imposed. 〔Basis Laws：The Taxation Act, Part XI and Fourteenth Schedule〕
Status of Past Projects	Under ongoing Grant Aid project in Malawi, a Japanese contractor has deducted WHT from payments for specified services and remitted the collected taxes to MRA. Hence, corporate tax is not expected to be a problem during the Project.

(2) Fiscal levies and taxes on their personal income (Personal income tax)

Name	Pay As You Earn (PAYE)
Taxable Object	Income accruing in Malawi or derived from, whether or not the individual is resident, is taxable.
Tax Rate	PAYE shall be exempted for Japanese contractors for the Project because they do not benefit from an income generated within Malawi through the Project. Meanwhile, it shall be imposed on Japanese contractors when they hire local labors for the Project. PAYE is progressive tax rate from 0 to 35%. Tax rates are as follows.

	<table><tr><th>Tax Items</th><th>Tax Rates</th></tr><tr><td>Pay As You Earn</td><td>●The first 30,000 MWK : 0% ●The next 5,000 MWK : 15% of Gross Income ●The next 2,965,000 MWK : 30% of Gross Income ●The excess of 3,000,000 MWK : 35% of Gross Income</td></tr></table> Source: The Survey Team If employee receives a gross salary of 200,000 MWK per month, (5,000MWK×15%)+{(200,000MWK-35,000MWK)×30%}＝ 50,250 MWK
Basis Laws	The Taxation Act, Part VI and Customs VAT and Taxation Amendments 2017
Tax Exemption Procedure, Application Authority, Required Time	【Tax Exemption is NOT available】 An employer who employs people whose earnings exceed 30,000 MWK per month or 360,000 in a year is required to register the details of employers/employees (Form P1) to MRA. An employer shall calculate the amount of tax every month and remit it to MRA no later than 14th day from the end of the month.
Status of Past Projects	Under ongoing Grant Aid project in Malawi, a Japanese contractor has calculated the amount of PAYE every month and remitted to MRA. Hence, PAYE is not expected to be a problem during the Project.

(3) Value Added Tax（VAT）

Name	Value Added Tax (VAT)
Taxable Object	VAT is an indirect tax on commodities and services in purchasing. VAT shall be payable at point of importation into the country.
Tax Rate	Standard rate is 16.5% of the price for both VAT and Import VAT. However, Import VAT shall be exempted on importation of specific types of machinery such as Crane Lorries and Mobile Drilling Derricks.
Basis Laws	Value Added Tax Act, 2005
Tax Exemption Procedure, Application Authority, Required Time	【Tax Exemption is available (Prior-exemption)】 An executing agency (Ministry and Agency) shall prepare and submit the followings to MRA; a letter to apply for free status of VAT, G/A, a copy of the contract with a contractor and a bill of quantity. After these documents are approved, VAT can be exempted in advance through the submission of an approved letter and Form ST14, which describes a list of procured equipment. When the name of a contractor written in the approved letter, a contractor allows to apply, modify and add ST 14 directly to MRA. TPIN is required for a contractor to deal with the form; foreign and recipient-country contractors are

	not distinguished in the registration conditions nor in the registration procedures. It takes approximately a month for a letter to be approved. Tax shall be exempted for specific types of machinery, which is not subject to taxation, without the above described procedures.
Status of Past Projects	Under ongoing Grant Aid project in Malawi, a local contractor has prepared and submitted a bill of quantity on behalf of a Japanese contractor to receive a tax exemption. Hence, VAT is not expected to be a problem during the Project.

(4) Duties and related fiscal charges with respect to the import and/or re-export of materials and equipment (Customs)

Name	Custom Duties
Taxable Object	Depending on types of im/exporting goods (Details are written in basis laws)
Tax Rate	Depending on types of im/exporting goods (Details are written in basis laws). Custom duties and Import VAT exemption is on specific types of import machinery such as Crane Lorries and Mobile Drilling Derricks. Custom duties is free, while VAT remains payable on importation of specific types of machinery such as solar panels, fuses and transformers. In addition, if goods are produced and imported from Southern African Development Community (SADC), custom duties are free while Import VAT remains payable at 16.5%.
Basis Laws	Custom duties and Exercise Act under VAT Act
Tax Exemption Procedure, Application Authority, Required Time	【Tax Exemption is available (Prior-exemption)】 An executing agency (Ministry and Agency) shall prepare and submit the followings to MRA; a letter to apply for free status of custom duties, G/A, a copy of the contract with a contractor and a bill of quantity. Tax exemption procedures require an approved letter and Customs and Exercise Declaration Form 12, prepared by authorized customs clearing agent by MRA. Tax can be exempted in advance though the submission of these documents at bonded area in Malawi (either boarders between Mozambique and Malawi or dry ports in Lilongwe). In customs clearance, an executing agency shall be present and sign the paper. Regarding re-exporting equipment, custom duties can be exempted in advance through the submision of an approved letter and detailed description of equipment to be re-exported. It takes approximately a month from application to approval. Tax shall be exempted for specific types of machinery, which is not subject to taxation, without the above described procedures.
Status of Past	Under ongoing Grant Aid project in Malawi, a local contractor has prepared and

Projects	submitted a bill of quantity on behalf of a Japanese contractor to receive a tax exemption. Hence, Custom Duty is not expected to be a problem during the Project.

(5) Other Taxes

Name	Fringe Benefit Tax (FBT)
Taxable Object	Fringe Benefit means any economic benefits aside from wages and salaries, provided by an employer to an employee. Mainly, motor vehicles, school fees and interests on the loan at a lower rate is provided in Malawi.
Tax Rate	Tax rates for major items are as follows. Source: The Survey Team
Basis Laws	The Taxation Act, Part IXA
Tax Exemption Procedure, Application Authority, Required Time	【Tax Exemption is NOT available】 An employer who provide fringe benefits to an employee shall register for FBT (form FBT1) within 14days after the provision. MRA provides Form FBT2 for remittance. An employer shall calculate the FBT quarterly and make a payment to MRA Domestic Taxes Office (Petroda Glass House, Lilongwe) within 14days from the end of each quarter.
Status of Past Projects	FBT is not expected to be a problem during the Project.

Tax Items	Tax Rates
Fringe Benefit Tax	●Provision of Motor Vehicles : 15% of Original cost ●Provision of School Fees : 50% of School fees ●Provision of interests on the loan at a lower rate : Difference rate from commercial lending rate

Collected Data List

No.	Name	Electric data /document	Original/copy	organization	year
1	LWB Annual Business Plan for 2012 - 2013	Electric data	Copy	LWB	2011
2	LWB ANNUAL REPORT 2013-2014	Electric data	Copy	LWB	2014
3	LWB ANNUAL REPORT 2014-2015	Electric data	Copy	LWB	2015
4	LWB ANNUAL REPORT 2015-2016	Electric data	Copy	LWB	2016
5	LWB Financial Statement 2011	Electric data	Copy	LWB	2011
6	LWB Financial Statement 2013	Electric data	Copy	LWB	2013
7	LWB Financial Statement 2014	Electric data	Copy	LWB	2014
8	LWB Financial Statement 2015	Electric data	Copy	LWB	2015
9	LWB Financial Statement 2016	Electric data	Copy	LWB	2016
10	LWB Financial Statement Draft 2012 final draft	Electric data	Copy	LWB	2012
11	LWB Lilongwe areas demarcated by pressure zones	Electric data	Copy	LWB	2017
12	LWB Pressure Zone	Electric data	Copy	LWB	2017
13	LWB Staff List JUNE 2017	Electric data	Copy	LWB	2017
14	LWB 2015-2020 Strategic Plan	Electric data	Copy	LWB	2015
15	LWB Customer Satisfaction Survey	Electric data	Copy	LWB	2016
16	LWB Infrastructure Investment Plan	Electric data	Copy	LWB	2016
17	LWB NRW Reduction Strategy Paper	Electric data	Copy	LWB	2016
18	LWB Priority Investment Program	Electric data	Copy	LWB	2016
19	LWB Schematic	Electric data	Copy	LWB	2016
20	LWB Institutional Analysis	Electric data	Copy	LWB	2016
21	LWB DIVISIONAL PERFORMANCE REPORTS JUNE 2013	Electric data	Copy	LWB	2013
22	LWB Divisional Financial Reports June 2014	Electric data	Copy	LWB	2014
23	LWB MA 2014-15 REVENUE BUDGET	Electric data	Copy	LWB	2014
24	LWB MA 2015-16 REVENUE BUDGET	Electric data	Copy	LWB	2015
25	LWB MA 2017-18 REVENUE BUDGET	Electric data	Copy	LWB	2017
26	LWB Budgets 2013-14	Electric data	Copy	LWB	2013
27	LWB June 2016 YEAR END DIVISIONAL EXPENDITURE REPORT	Electric data	Copy	LWB	2016
28	LWB June Divisional Accounts 2015	Electric data	Copy	LWB	2015
29	LWB JUNE 2017 DIVISIONAL EXPENDITURE	Electric data	Copy	LWB	2017
30	MAWID Brief Supervisory Report for SRWSIHL Project in Nkhotakota, July	Electric data	Copy	MAIWD	2017
31	MAWID Brief Supervisory Report for SRWSIHL Project in Mangochi, June	Electric data	Copy	MAIWD	2017
32	MAWID Brief Supervisory Report for SRWSIHL Project in Rumphi, July	Electric data	Copy	MAIWD	2017
33	MAWID Brief Supervisory Report for SRWSIHL Project in Ntcheu,June	Electric data	Copy	MAIWD	2017
34	MAWID Brief Supervisory Report for SRWSIHL Project in PHALOMBE, No_5	Electric data	Copy	MAIWD	2016
35	MAWID Brief Supervisory Report for SRWSIHL Project in PHALOMBE, No_6	Electric data	Copy	MAIWD	2016
36	MAWID BRIEF REPORT ON CONSTRUCTION OF BOREHOLES UNDER THE SRWSIHL PROJECT	Electric data	Copy	MAIWD	2017
37	Consultancy Services for National Hydrogeological and Water Quality Mapping Final Geophysical Survey Report	Electric data	Copy	MAIWD	2015
38	Hydrogeological and Water Quality Mapping Consultancy in Shire River Basin Draft Geophysical Survey Report	Electric data	Copy	MAIWD	2017
39	Consultancy Services for National Hydrogeological and Water Quality Mapping Draft Exploratory Drilling Report	Electric data	Copy	MAIWD	2015
40	Water Resources Investment Strategy Component 1 – Water Resources Assessment Annex V – Groundwater	Electric data	Copy	MAIWD	2011
41	MALAWI Customs and Excise Tariff 2017-2018	Electric data	Copy	MRA	2017
42	RECEIPTS AND EXPENDITURES FOR BOREHOLE TREASURY FUND FOR 4 YEARS PERIOD	Electric data	Copy	MAIWD	2013
43	RECEIPTS FOR MONTHLY BOREHOLE TREASURY FUND 2016/2017	Electric data	Copy	MAIWD	2015
44	MALAWI DEVELOPMENT BUDGET TREND FOR 3 YEARS	Electric data	Copy	MAIWD	2015
45	WATER AND IRRIGATION DEVELOPMENT 3 YEARS TREND BUDGET (OTHER RECURRENT TRANSACTION)	Electric data	Copy	MAIWD	2015
46	PUBLIC FINANCE MANAGEMENT ACT (Cap. 37:02) PUBLIC FINANCE MANAGEMENT (BOREHOLE CONSTRUCTION AND GROUND WATER MANAGEMENT FUND) ORDER, 2013	Electric data	Copy	MAIWD	2013
47	MALAWI RURAL WATER SUPPLY INVESTMENT PLAN- ANNEX II VOLUME II - GROUNDWATER RESOURCES ASSES	Electric data	Copy	MAIWD	2014
48	MALAWI RURAL WATER SUPPLY INVESTMENT PLAN 2014-2020	Electric data	Copy	MAIWD	2014
49	DRAFT 2015-2016 SECTOR PERFOMANCE REPORT FOR WATER, IRRIGATION AND SANITATION SECTOR	Electric data	Copy	MAIWD	2015

Recommendations for Groundwater Development

Recommendations for Groundwater Development

(1) Water Resource Development in Shallow Aquifers (Expansion of existing boreholes)

Boreholes of 100 m or deeper do not exist in Malawi. Most groundwater sources are shallow aquifers (first-level aquifers), and are sourced from either weakly confined or unconfined stratum water at 10 to 60 m and fissure water at a depth of 30 to 95 m. According to the interpretation of the existing data and documents, the existing groundwater storage is not fully utilized at some shallow aquifers and thus, additional amount of water is expected through the construction of new boreholes. In areas where existing boreholes yield 5 ℓ/s or more at present, the same aquifers have a capacity to withdraw increased volumes of water. Thus, yields can be increased through the enlargement of borehole diameters (6 or 8-inch) and use of large-scale submersible pumps. In addition, when aquifers exist in the same groundwater basin, it is easier to operate and maintain fewer large-diameter boreholes than a larger number of small-diameter boreholes. Moreover, the development of shallow aquifers can contribute to maintaining sustainable yields as well as preserving groundwater. The evaluation of shallow aquifer areas (boreholes) where an increased yield is expected is as follows.

Table 1: List of existing boreholes where increased yields expected for large-diameter boreholes

Survey Site				Borehole Drilling Data		Pumping Test Data				Groundwater Storage
No.	Area	District	Site	Depth (m)	Aquifers	Yields (ℓ/s)	SWL (m)	DWL(m)	Drawdown (m)	Evaluation
1	North	Karonga	Kaporo	100	Highly weathered sedimentary	10.0	3	11	8	A
2		Chitipa	Mwenechendo	100	Slightly Factured Granite	1.0	14	36	22	D
3		Karonga	Mulale	64	Highly weathered sedimentary sand	10.0	14	24	10	A
4		Karonga	Nyungwe	100	Highly weathered sedimentary sand	10.0	9	19	10	A
5		Chitipa	Nthalire	102	Slightly fractured Gneiss & Granite	5.0	9	45	36	B
6		Rumphi	Mzokoto	100	Weathered factured Gneiss	1.0	15	23	8	C
7		Rumphi	Chakoma	80	Sand and Weathered Gneiss with quartz	5.0	21	61	40	B
8		Rumphi	Katumbi	63	Weathered Gneiss with quartz	0.3	12	54	42	D
9		Chitipa	Chitipa	102	Weathered Gneiss	1.0	17	27	10	C
10		Mzimba	Mzimba	93	Slightly weathered grey Granite	0.1	13	53	40	D
11		Mzimba	Madede	101	Weathered factured Gneiss	1.0	13	49	36	D
12		Nkhata Bay	Usisya	–	No data	X	1	43	42	D
13		Nkhata Bay	Nkhata Bay	99	Slightly weathered Granite with Fractured	0.3	13	55	42	D
14	Central	Nkhotakota	Kamphambale	101	Sandy sediment & depHighly weathered Gneiss	10.0	7	29	22	A
15	North	Mzimba	Katete	101	Weathered Gneiss with fractured	0.5	17	26	8.5	D
16	Central	Kasungu	Kaluluma	104	Gneiss Quartz vein with fractured	0.5	15	40	25	D
17		Mzimba	Liwaladzi	70	Alluvial sand (Highly weathered sedimentary)	10.0	7	8	0.7	A
18		Kasungu	Kapelula	95	Factured Gneiss	5.0	X	X	X	X
19		Kasungu	Mphompwa	95	Factured Gneiss	0.3	13	46	33	D
20		Ntchisi	Malomo	101	Slightly Factured Granite	0.3	8	X	X	D
21		Nkhotakota	Mwansambo	55	Alluvial sand (weathered sedimentary)	0.5	12	34	22	D
22		Dowa	Chigudu	98	Highly weathered Gneiss with fractured	0.5	18	40	22	D
23		Kasungu	Linyangwa	95	Weathered Gneiss with fractured	2.5	10	45	35	D
24		Kasungu	Liswandwa	100	Weathered Gneiss & mica with fractured	2.5	6	27	21	C
25		Salima	Khombedza	95	Weathered Gneiss with fractured	1.0	9	24	15	D
26		Mchinji	Mkanda	101	Weathered Gneiss with fractured	1.0	5	28	23	D
27		Mchinji	Tembwe	95	Slightly weathered Quartzitic rock with Fractured	2.5	6	21	15	C
28		Lilongwe	Lumbadzi	101	Weathered Quartzitic Gneiss with Fractured	0.5	18	42	24	D
29		Lilongwe	Namitete	101	Weathered Gneiss & Quartz with Fractured	1.0	5	43	38	D
30		Lilongwe	Simeon	101	Weathered Gneiss, Quartz with Fractured	1.0	4	X	X	X
31		Lilongwe	Nathenje	93	Fractured Graphatic Gneiss	0.3	15	58	43	D
32		Dedza	Ntenje	82	Fractured Gneiss, Mica	1.0	2	X	X	?
33	South	Mangochi	Chantulo	80	Alluvial sand (weathered sedimentary)	5.0	10	16	6	A
34		Mangochi	Katema	95	Highly Weathered Gneiss with Fractured	2.5	25	26	0.8	B
35		Mangochi	Mdinde	100	Sand and Weathered Gneiss	1.0	4	40	36	D
36		Machinga	Nselema	99	Gneiss with fractured	2.5	5	15	10	C
37		Machinga	Nsanama	100	Gneiss with fractured	2.5	5	17	11.5	C
38		Zomba	Songani	81	Gneiss with fractured	1.0	7	25	18	D
39		Zomba	Magomero	100	Weathered Gneiss with fractured	5.0	6	24	18	A
40		Mangochi	Kadongo	101	Weathered Gneiss, Mica with fractured	5.0	10	X	X	X
41		Mangochi	Malindi	80	Alluvial weathered sedimentary	10.0	8	21	12.5	A

A:High Possbility, B:Medium Possibility, C: Low Possibility, D: Least Possibility

(2) Water Resource Development in Deep Aquifers (Implementation of Exploratory Drilling Survey)

1) Significance of Exploratory Drilling Survey

The results of the geophysical prospecting conducted by MAIWD estimated the possibility of groundwater storage at a depth of 100 m or deeper. However, the estimation is made only based on the changes in electrical resistivity value and thus, a verification of results of the geophysical prospecting against actual geological conditions is required to validate the result. Under present circumstances, it is not possible to grasp the geological situation with existing equipment because rigs capable of drilling more than 100 m do not exist in Malawi. However, it is possible to drill to such depths if a drilling rig is procured from a neighboring country such as South Africa, Kenya, or Tanzania. Drilling to such depths will provide hydrogeological data such as the underground structure and form of groundwater storage. Such data, which do not exist in Malawi, is valuable as it enables verification of the results of geophysical prospecting. In addition, it is very useful information, particularly when developing a concrete development plan for deep aquifers. Therefore, implementation of an exploratory drilling survey of deep layers is recommended in order to grasp the situation of underground water storage and the entire groundwater basin of Malawi.

2) Candidate Sites for Exploratory Drilling Survey

The exploratory drilling survey shall be conducted at sites that meet the following criteria, based on the results of the geophysical prospecting exploration by MAIWD.

North and Central Region

- Sites where the ρ-a curve is [(b) Ascending-type] or [(d) Mountain-type] and random variations (turbulence) of the apparent resistivity value are observed at a depth of 150 m or more
- Sites where the ρ-a curve is [(a) Bowl-type] or [(b) Ascending-type)] and turbulence of the apparent resistivity value are not observed as the depth becomes deeper (sites where the presence or absence of continuity of the curve in the depth direction of groundwater basin needs to be confirmed)
- Sites where the ρ-a curve is [(c) Descending-type] and the apparent resistivity value at a depth of 150 m or more is supposed to be 80 Ohm*m or less continuously

South Region

- Sites where the ρ-a curve is [(b) Ascending-type] or [(d) Mountain-type] and random variations (turbulence) of the apparent resistivity value are observed at a depth of 150 m or more
- Sites where the ρ-a curve is [(c) Descending-type] and the apparent resistivity value at a depth of 150 m or more is 30 Ohm*m or less continuously

In the Hydrogeological Survey carried out between 2014 and 2015, the sites satisfying the above criteria, that is, the candidate sites of the exploratory drilling survey, are 33 sites (A rating: 10 sites, B rating: 8 sites, C rating: 4 sites, D rating: 11 sites). The details of each of the candidate sites for the survey are as follows. The location maps of these candidate sites are shown in the attached documents 1 and 2.

Table 2: List of candidate sites for exploratory drilling survey

				Geophysical Prospecting Survey Results					Groundwater Storage	
No.	Area	District	Site	Survey Depth (m)	Prediced Aquifer Depth (m)	Resistivity (Ohm*m)	Hydrogeology	Groundwater Aquifer	Evaluation	Predicted Depth (m)
1	North	Karonga	Kaporo	150	40 -150	85	Quaternary alluvium & Weathered Rock	Stratum & Fissure	A	200
2		Chitipa	Mwenechendo	150	50 -120	85	Weathered Rock or Fracture	Fissure	D	200
3		Karonga	Mulale	150	50 - 150	32-70	Highly weathered sedimentary & Fracture	Stratum & Fissure	A	200
5		Chitipa	Nthalire	150	40 - 70	120 - 1000	Weathered rock with Fracture	Fissure	B	200
6		Rumphi	Mzokoto	150	40 - 150	80~140	Weathered Rock or Fracture	Fissure	B	200
8		Rumphi	Katumbi north	150	20 - 100	38 - 3000	Weathered Rock or Fracture	Fissure	D	200
9		Chitipa	Chitipa	150	20 - 90	110 - 1000	Saprolite or Weathered rock	Fissure	D	200
10		Mzimba	Mzimba	100	30 - 100	220 - 1500	Weathered gneiss / fractures	Fissure	D	200
11		Mzimba	Madede	100	40-80	80 - 140	Saprolite or Weathered rock	Fissure	D	200
15	Central	Nkhotakota	Kamphambale	150	80~150≦	30~85	Low Resistive Rocks	Fissure	A	200
16		Mzimba	Kaluluma	150	10 - 70	57 - 5000	Fracture in Hard rock	Fissure	D	200
18		Kasungu	Kapelula	150	40 - 120	30 - 3000	Weathered Rock with Fracture	Fissure	B	200
21		Nkhotakota	Mwansaambo	100	10 -150	110	Weathered Bedrock (Sand, Gravel, etc.)	Stratum & Fissure	D	200
24		Kasungu	Lisandwa	150	80~150≦	1,400	Weathered Rock with Fracture	Fissure	A	200
27		Mchinji	Tembwe	150	80~150	100~500	Weathered rock (Granites, Gneiss) with Fracture	Fissure	C	200
28		Lilongwe	Lumbadzi	150	80~150	110- 3500	Weathered rock with Fracture	Fissure	D	200
30		Lilongwe	Simeon	150	40 - 100	70 - 4000	Weathered rock with Fracture	Fissure	D	200
31		Lilongwe	Nanthenje	150	50~150≦	230~3,000	Weathered Rock with Fracture	Fissure	B	200
33	South	Mangochi	Chantulo*	150	60~150≦	5~7	Low Resistivity Zone/Saline Aquifer	Stratum	A	200
36		Machinga	Nselema-Button	150	50~150≦	120~920	Weathered Rock with Fracture	Fissure	B	200
39		Zomba	Magomero	100	50~150≦	50 - 860	Weathered Rock with Fracture	Fissure	A	200
41		Mangochi	Malindi	100	20-150≦	4 - 100	Weathered Sedimentary layer	Stratum/Fracture	A	200
S-4		Chikwawa	Ngabu	400	90~200	3~20	Unconsolidated Sediment	Stratum/Fracture	B	200
S-5		Mangochi	Lidunde	400	70 - 200	110~500	Weathered gneiss	Fissure	C	200
S-11		Balaka	Namalomba*	400	100~300	5~10	Unconsolidated Sediment from Lake Malombe	Stratum	A	200
S-12		Mangochi	Chisawa*	400	90 - 300	3~10	Unconsolidated sediments from Shire River	Stratum	C	200
S-16		Balaka	Buke	400	40~230	400~2,000	Weathered Gneiss/Fractures	Fissure	B	200
S-19		Chikhwawa	Mitondo*	400	80 ~ 250	10~30	Unconsolidated Sediments	Stratum	A	200
S-20		Nsanje	Tiza*	400	80 - 220	3~8	Unconsolidated sediments	Stratum	C	200
S-21		Chikwawa	Chambulika	400	60 ~ 180	35~65	Basalt Lava/Pyroclasitic Flow	Fissure	A	200
S-29		Chikhwawa	Namalidi	400	100 ~ 200	4~20	Unconsolidated Sediments from Shire River	Stratum	B	200
S-30		Chikwawa	Ngowa	400	20 - 120	2500 - 4000	Weathered gneiss with fractures	Fissure	D	200
S-31		Mulanje	Kwalala	400	50 - 150	50 - 3000	Weathered gneiss with fractures	Fissure	D	200

* Saline groundwater may exist in shallow aquifers

A:High Possbility, B:Medium Possibility, C: Low Possibility, D: Least Possibility

(3) Water Source Development based on Malawi Rural Water Supply Investment Plan

In Malawi Rural Water Supply Investment Plan, MAIWD plans to construct shallow boreholes at market centers, a center of economy at rural areas. 32 market centers are selected mainly based on the

size of the population in the centers and current water supply condition. Construction of a total of 115 shallow boreholes is aimed for by 2020 according to the plan. As a result of organizing data regarding these 32 market centers and 73 sites where the geophysical prospecting was conducted, it was found that the locations were matched at 3 sites (Kaporo, Nyungwe, Malindi). In addition, 7 surveyed sites (Lisandwa, Nanthenje, Tembwe, Nseleme, Namalonba, Buka, Tiza) were found near market centers and to have the same wide-area hydrological structure. Among these 10 sites, 3 sites (A rating) have the possibility of high groundwater storage at shallow layers. On the other hand, at deep layers, 5 sites (A rating) are likely to have high groundwater storage and 3 sites (B rating) are likely to have medium groundwater storage. It is noted that even if poor groundwater storage is evaluated at the shallow layer, it can be assessed to have a high potential when the deep layer is evaluated as high groundwater storage.

Table 3: Collation of market center and geophysical prospecting sites

Area	District	Market Center	Site	Evaluation on Groundwater Storage		Proposed No. of Boreholes**
				Shallow Aquifers	Deep Aquifers	
North	Karonga	Kaporo	Kaporo	A	A	3
		Nyungwe	Nyungwe	A	A	2
Central	Kasungu	Chamama	Lisandwa	C	A	4
	Lilongwe	Namitete	Nanthenje	D	B	6
	Mchinji	Kapiri	Tembwe	C	C	5
South	Mangochi	Malindi	Malindi	A	A	5
		Chilipa	Nseleme	C	B	2
	Balaka	Phalula	Namalonba*	-	A	5
		Ulongwe	Buke*	-	B	3
	Thyolo	Thekerani	Tiza*	-	C	5

*Evaluations were not made owing to a partial lack of drilling data

** Number of boreholes are proposed to be drilled by 2020 in Malawi Rural Water Supply Investment Plan

A:High Possbility, B:Medium Possibility, C: Low Possibility, D: Least Possibility

Among 10 sites shown in the above table, 1 site is located in North District, 3 sites in Central District and 3 sites are in South District. As a reference to future development of water resource, the Project evaluated the capacity of shallow and deep aquifers of each District based on topographic background and hydrogeological features. Details of each District are as shown below.

Karonga

Mountainous area is distributed in an arc shape from northern part of western region of Malawi, adjacent to the boarder of Tanzania to the southwest side. The underground geology of the mountainous area is composed of granite and gneiss rocks in disorder. Although fissure water is stored in these rocks, the distribution of cracks and fracture zones is small. Thus, it seems that little amount of fissure water is expected. A vast plateau and peneplain continued from the mountainous area over the northeastern part to the shores of Lake Malawi. Diluvial sediments in the Cenozoic era are thinly deposited at the surface soil, and its lower part is composed of granite and gneiss rocks. In addition, sediments during the diluvial and alluvial epoch are distributed thickly near the shores of Lake Malawi, and weakly confined or unconfined stratum water is stored in these sediments. On the other hand,

fissure water is partially preserved in plateau and peneplain areas, though little amount of water is expected.

Kasungu

The underground geology of mountainous area roughly consists of gneiss rocks. The surface soil of peneplain at the western peneplain is covered with thin diluvial sediments and its lower part is composed of granite and gneiss rocks. Fissure water is stored continuously from the first aquifer to the second aquifer throughout almost all areas. Thus, the possibility of additional water withdrawal from the shallow aquifer, that is, higher groundwater storage beyond the current situation is not overly expected. Therefore, this area can be considered a high priority for groundwater development (fissure water) at deeper layers (deeper than 100 m).

Lilongwe

Mountainous area is composed of gneiss rocks. Peneplain in the western part consists of diluvial sedimentary layers and gneiss rocks are distributed beneath. Weakly confined or unconfined stratum water is preserved in the first layer at peneplain, while fissure water is stored at mountainous area. Thus, additional water can be withdrawn from the shallow aquifer in peneplain land.

Mchinji

Peneplain consists of diluvial sediments and its lower part is composed of gneiss rocks. Granitic metamorphic rocks are distributed at mountainous area on the southwest part. Weakly confined or unconfined stratum water exists in the first aquifer at peneplain, and fissure water exists in mountainous area on the southwest part. Thus, additional water can be withdrawn from the shallow aquifer in peneplain land.

Mangochi

In lowland, sediments deposited during the diluvial and alluvial epoch are thickly distributed, originating from Lake Malawi and Shire River. The mountainous area on the east is composed of granitic metamorphic rocks. The surface soil of the peneplain and plateau consists of diluvial sediments, while its lower part is composed of granitic metamorphic rocks. Additional water can be expected from the shallow aquifer in lowland area because weakly confined or unconfined stratum water exist and the result of the pumping test of existing boreholes is favorable. However, water quality needs to be paid attention because the existence of saline groundwater is confirmed in the first aquifer for some areas.

Balaka

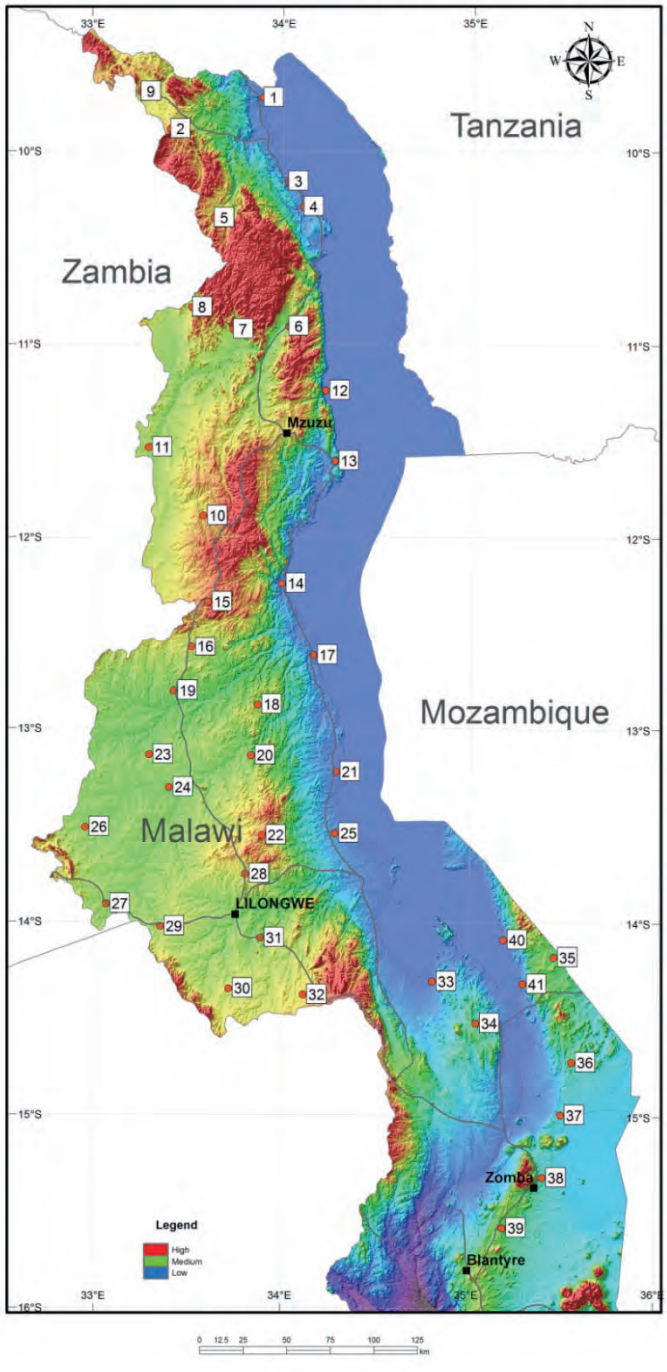
In lowland valley, sediments during the diluvial and alluvial epoch are distributed, originating from the Shire River. Eastern and western mountainous area surrounding the lowland valley is composed of granitic metamorphic and gneiss rocks. The surface soil of the peneplain and plateau consists of

diluvial sediments and its lower part is composed of granitic metamorphic rocks. Weakly confined or unconfined stratum water in lowland valley and fissure water in the slope at the base of eastern and western mountains are presented respectively. Thus, additional water can be expected from the shallow aquifer in lowland valley. However, water quality needs to be paid attention because the existence of saline groundwater is estimated in the first aquifer for some areas.

Thyolo

In lowland valley, sediments during the diluvial and alluvial epoch are distributed, originating from Shire River and its lower part consists of granitic metamorphic and gneiss rocks. Weakly confined or unconfined stratum water in lowland valley and fissure water in the slope at the base of eastern and western Shire River valley are preserved respectively. Thus, additional water can be expected from the shallow aquifer in lowland valley. However, water quality needs to be paid attention because the existence of saline groundwater is estimated in the first aquifer for some areas.

Attachment 1: Candidate sites for exploratory drilling survey in the North and Central Area (22 out of 41 sites)

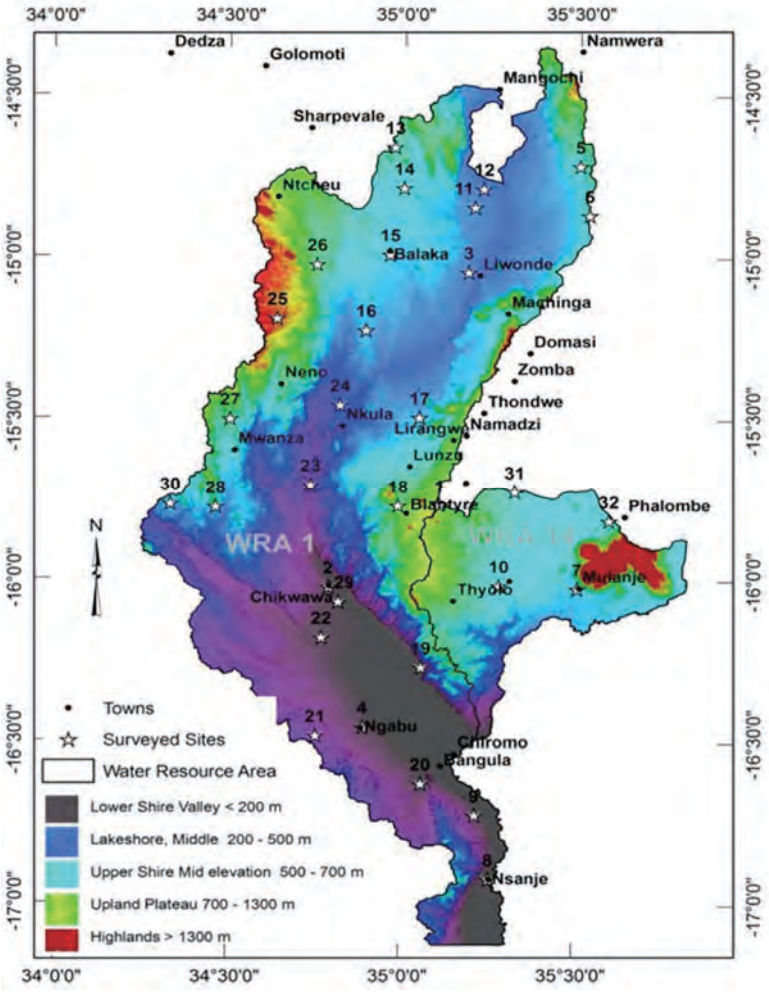


No.	Area	District	Site
1	N.	Karonga	Kaporo
2		Chitipa	Mweneche-ndo
3		Karonga	Mulale
4		Karonga	Nyungwe
5		Chitipa	Nthalire
6		Rumphi	Mzokoto
7		Rumphi	Chakoma
8		Rumphi	Katumbi
9		Chitipa	Chitipa
10		Mzimba	Mzimba
11		Mzimba	Madede
12		Nkhatabay	Usisya
13		Nkhatabay	Nkhata Bay
14	C.	Nkhotakota	Kampham-bale
15	N.	Mzimba	Katete
16	C.	Kasungu	Kaluluma
17		Nkhotakota	Liwaladzi
18		Kasungu	Kapelula
19		Kasungu	Mphompwa
20		Ntchisi	Malomo
21		Nkhotakota	Mwansambo
22		Dowa	Chigudu
23		Kasungu	Linyangwa
24		Kasungu	Lisandwa
25		Salima	Khombedza
26		Mchinji	Mkanda
27		Mchinji	Tembwe
28		Lilongwe	Lumbadzi
29		Lilongwe	Namitete
30		Lilongwe	Simeon
31		Lilongwe	Nathenje
32		Dedza	Ntenje
33	S.	Mangochi	Chantulo
34		Mangochi	Katema
35		Mangochi	Mdinde
36		Machinga	Nselema
37		Machinga	Nsanama
38		Zomba	Songani
39		Zomba	Magomero
40		Mangochi	Kadongo
41		Mangochi	Malindi

Candidate Sites for Survey

Source: the Survey Team and Final Geophysical Survey Report (March 2015)

Attachment 2：Candidate sites for exploratory drilling survey in the Southern area (11 out of 32 sites)



No.	Area	District	Site
1	S.	Blantyre	Mzedi
2		Blantyre	Chikwawa
3		Balaka	Mmanga
4		Chikwawa	Ngabu
5		Mangochi	Lidunde
6		Mangochi	Ntaja
7		Mulanje	Mulanje
8		Nsanje	Nsanje
9		Nsanje	Mpepe
10		Thyolo	Mikaleti
11		Balaka	Namalomba
12		Mangochi	Chisawa
13		Mangochi	Malenga
14		Mangochi	Kapire
15		Balaka	Balaka
16		Balaka	Buke
17		Blantyre	Malaka
18		Blantyre	Chilomoni
19		Chikwawa	Mitondo
20		Nsanje	Tiza
21		Chikwawa	Chambuluka
22		Chikwawa	Tomali
23		Blantyre	Mpatseabwire
24		Neno	Malizakamba
25	C.	Ntcheu	Mokhotho
26		Ntcheu	Ntonda
27	S.	Mwanza	Chidoole
28		Mwanza	Msambangombe
29		Chikwawa	Namalindi
30		Chikwawa	Ngowa
31		Mulanje	Khwalala
32		Phalombe	Chileyeni

Candidate Sites for Survey

Source: the Survey Team and Hydrogeological and Water Quality Mapping Consultancy in Shire River Basin Draft Geophysical Survey Report (June 2017)